

COMPLIMENTARY

INDIAN COTTON COMMITTEE

MINUTES OF EVIDENCE

TAKEN BEFORE THE

INDIAN COTTON COMMITTEE

VOLUME III

IRRIGATION

MINUTES OF EVIDENCE FROM UNITED PROVINCES, CENTRAL PROVINCES,
NORTH-WEST FRONTIER PROVINCE, PUNJAB AND SIND.



CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1920

Agents for the Sale of Books Published by the Superintendent of Government Printing, India, Calcutta.

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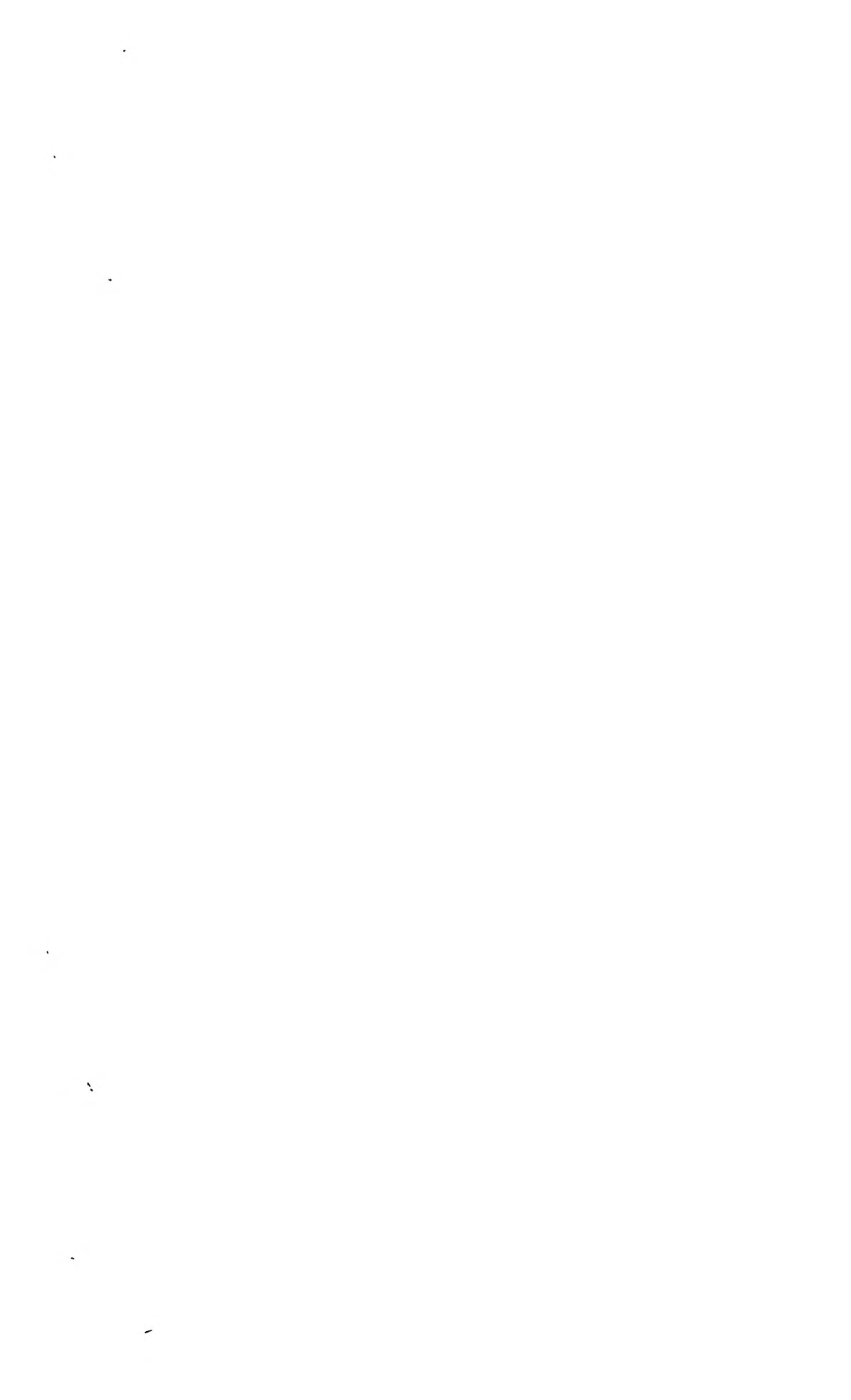
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NOTE.

It is regretted that it has been impossible to publish the evidence given before the Indian Cotton Committee earlier owing to the transfer of the Secretary to other duties in August, 1918. For convenience of reference, the evidence has been classified under the three heads, Agricultural, Irrigation and Commercial. Volumes I and II contain the Agricultural Evidence, Volume III the Irrigation Evidence and Volumes IV and V the Commercial Evidence. The evidence of a witness will, therefore, be found in one or other of these volumes according to its predominating character. The references in black type in the written statements are to the questions issued by the Committee which are printed at the commencement of each volume. Thus "(30) Local trade customs" shows that the paragraph is a reply to question 30. A glossary of the more common vernacular terms used in the evidence is appended.

F. NOYCE,
Secretary,
Indian Cotton Committee.

BOMBAY ; }
October 1st, 1919. }



Glossary of the more common vernacular terms used in the evidence.

Amin	Subordinate official of the Irrigation Department.
Arat	Commis on.
Aratya	Comm ssion agent.
Arhar	Pigeon pea (<i>Cajanus indicus</i>)
Bajra	Bulrush millet (<i>Pennisetum typhoideum</i>).
Bania	Village shop-keeper and money-lender.
Barani	Land dependent on rainfall.
Bhata	Lateritic soil in the Central Provinces.
Bhindi	Lady's finger (<i>Hibiscus esculentus</i>), a vegetable.
Bhusa	Crushed straw.
Bigha	A land measure, usually about three-eighths of an acre.
Bora	Bag of unpressed cotton of varying weight, generally five maunds.
Chari	Great millet (<i>Sorghum vulgare</i>) grown as a fodder crop.
Chaudhri	A headman.
Dalal	Broker.
Deshi	Indigenous.
Docra	Bag of unpressed cotton of varying weight, generally five maunds.
Ghats	Hills.
Gwar, gwara	Field vetch (<i>Cyamopsis psoralioides</i>), a fodder crop.
Hari	Cultivating tenant in Sind.
Inam	Land held on favourable terms or free of land revenue.
Juar	Great millet (<i>Sorghum vulgare</i>).
Kamdar	Fieldman: subordinate in the Agricultural Department.
Kan	Weight of lint obtained from unit weight of unginned cotton.
Kanungo	Subordinate revenue official in charge of a group of villages, known as Revenue Inspector in Madras and Circle Inspector in Bombay.
Kapas	Unginned cotton.
Karbi	Dry juar fodder.
Karnam	Village accountant.
Kharif	The autumn harvest.
Khurpa	Hand hoo similar in shape to a trowel.
Killa	Square of land usually equal to 1½ acre in area.
Kodo, kodon	A millet (<i>Paspalum scrobiculatum</i>).
Kumbu	Bulrush millet (<i>Pennisetum typhoideum</i>).
Kunbi	A cultivator.
Kutki	A pulse (<i>Dolichos biflorus</i>).
Lakh	One hundred thousand.
Mabajan	Money-lender.
Makki	Maize (<i>Zea mays</i>).
Malguzar	Landholder in the Central Provinces.
Mandi	Market.
Methi	Fenugreek (<i>Trigonella foenum græcum</i>).
Moth	A pulso (<i>Phaseolus aconitifolius</i>).
Mukhtiarkar	Revenue officer in charge of a <i>taluka</i> (q.v.) in Sind.
Mung	A pulso (<i>Phaseolus mungo</i>).
Patel	Village headman.
Patwari	Village accountant.
Phutties	Unginned cotton: Kapas.
Rabi	The spring harvest.
Rui	Lint.
Sahukar	Money-lender.
Sailab, Sailabi	Land irrigated by floods or percolation from a river.
San	Homp (<i>Crotalaria juncea</i>).
Senji	A fodder crop (<i>Melilotus parviflora</i>).
Shahtal	A fodder crop (<i>Trifolium resupinatum</i>)
Tahsil	Revenue sub-division of a district.

Tahsildar	Officer in charge of a <i>tahsil</i> , <i>taluk</i> or <i>taluka</i> (q.v.).
Taluk, taluka	Revenue sub-division of a district.
Til	Sesamum (<i>Sesamum indicum</i>).
Toria	An oil seed (<i>Brassica campestris</i>).
Tur	Pigeon pea (<i>Cajanus indicus</i>).
Urad	A pulse (<i>Phaseolus mungo</i>).
Varagu	Bulrush millet (<i>Pennisetum typhoideum</i>).
Zaildar	A rural notable appointed by Government. The head of a Zail or Circle of villages.
Zamindar	A landowner ; in the provinces visited by the Cotton Committee generally a peasant proprietor.

VOLUME III.

Irrigation.

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MINUTES OF EVIDENCE

TAKEN BEFORE THE

INDIAN COTTON COMMITTEE

VOLUME III.—Irrigation.

Questions issued by the Committee.

I.—AGRICULTURAL EXPERIENCE.

(a) "*Deshi*" short-staple cotton.

1. In what cotton growing districts have you been stationed and for what period in each? Have you been in actual touch with cotton cultivators?
2. What varieties of *deshi* short staple cotton are grown in the districts with which you are acquainted?
3. What is the average size of holdings in which cotton is grown and what proportion of the holding is under cotton?
4. What are the average yields and profits per acre?
5. What rotations are followed and what manures, if any, are applied?
6. How does the return to the cultivator of the different varieties of *deshi* short staple cotton compare with the return from (a) *deshi* long staple cotton, (b) other *deshi* crops, (c) exotic cottons?
7. Does the area under *deshi* short staple cotton fluctuate at all largely in the districts with which you are acquainted, and if so, is there any special reason for this? Is there any possibility of an increase under *deshi* short staple cotton and, if so, what are the factors which would limit that increase?
8. To what uses is the seed put? Is any seed selection practised and, if so, on what principles? Is seed selected for sowing specially hand ginned?
9. Please add any remarks you consider may be helpful to the Committee on the general economic state of the cotton growing districts with which you are acquainted.

N.B.—Please see note at end of Section (c) below.

(b) "*Deshi*" long staple cotton.

10. In what cotton growing districts have you been stationed and for what period in each? Have you been in actual touch with cotton cultivators?
11. What varieties of *deshi* long staple cotton are grown in the districts with which you are acquainted?
12. What is the average size of holdings in which cotton is grown and what proportion of the holding is under cotton?
13. What are the average yields and profits per acre of different varieties of *deshi* long staple cotton of which you have had experience? How do these compare with those of (a) *deshi* short staple cotton, (b) other *deshi* crops, (c) exotic cottons?
14. What rotations are followed and what manures, if any, are applied?
15. What, in your opinion, are the special conditions which would affect any increase in the area under *deshi* long staple cotton in the districts with which you are acquainted, e.g., length of ginning season, irrigation available, climatic considerations, competition with food crops, limitation owing to necessity of observing rotations, labour supply, etc?
16. Do you consider that, in the cotton growing tracts with which you are acquainted, the right varieties of *deshi* long staple cotton are being pushed in the right districts or whether still superior types could be introduced?
17. What measures would you recommend to prevent the mixing of *deshi* long staple cotton with (i) *deshi* short staple cotton, (ii) exotic cotton (a) in the field, (b) in the factory?
18. To what uses is the seed put? Is any seed selection practised and, if so, on what principles? Is seed selected for sowing specially hand ginned?
19. Please add any remarks you consider may be helpful to the Committee on the economic state of the cotton growing districts with which you are acquainted.

N.B.—Please see note at end of Section (c) below.

(c) *Exotic* cotton.

20. In what cotton growing districts have you been stationed and for what period in each? Have you been in actual touch with cotton cultivators?
21. What varieties of exotic cotton are grown in the districts with which you are acquainted?
22. What is the average size of holdings in which cotton is grown and what proportion of the holding is under cotton?

QUESTION ISSUED BY THE COMMITTEE.

[Continued.]

23. What are the average yields and profits per acre of the different varieties of exotic cotton of which you have experience? How do these compare with those of (a) *deshi* short staple cotton, and (b) *deshi* long staple cotton, (c) other *deshi* crops?

24. What rotations are followed and what manures, if any, are applied?

25. What, in your opinion, are the special conditions which would affect any increase in the area under exotic cotton in the districts with which you are acquainted, e.g., length of ginning season, irrigation available, climatic considerations, competition with food crops, limitation owing to necessity of observing rotations, labour supply, etc?

26. Do you consider that, in the cotton growing tracts with which you are acquainted, the right varieties of exotic cotton are being pushed in the right districts or whether still superior types could be introduced?

27. What measures would you recommend to prevent the mixing of exotic cotton with (i) *deshi* short staple cotton, (ii) *deshi* long staple cotton (a) in the field, (b) in the factory?

28. What is your opinion as to the desirability of importing seed direct from America or Egypt as required as against relying on selected seed grown in India?

29. Please add any remarks you consider may be helpful to the Committee on the economic state of the cotton growing districts with which you are acquainted?

N.B.—The Committee would be obliged if you would give them your views as to the best organization for handling cotton in your province. Under this head you might consider research in connexion with improvement of the plant, establishment of seed farms for the production of improved seeds, district staff necessary and the regulation of buying agencies and ginning factories.

II.—COMMERCIAL ASPECT.

30. Give, as fully as possible, an account of local trade customs with which you are acquainted in regard to the marketing of the cotton crop, in particular as regards any systems of agency, advances, future buying or contracts.

31. What are the commercial names of the various grades of cotton with which you are acquainted and from what areas do they come? Do you regard them as suitable and, if not, what alterations would you suggest? Can you suggest any means by which the commercial names could be standardized, i.e., of securing that the same name should be used for the same cotton from whatever locality it comes?

32. What do you consider is the best form of buying agency?

III.—STATISTICAL.

33. Do you consider that the cotton forecast, as at present published, is sufficiently accurate as far as your province is concerned? If not, can you suggest any way in which it could be improved?

34. Can you suggest any methods by which the statistical information published by Government in regard to cotton other than the forecasts, e.g., the cotton press return, could be made of greater use to the cotton trade?

35. What are your views in regard to the daily publication of Liverpool and Bombay cotton prices at up-country markets?

IV.—MANUFACTURE.

(a) Ginning and Pressing.

36. What class of gins and presses do you use and how many have you in your factory?

37. What is the size of the bale produced by your factory?

38. What is your opinion as to the relative merits of saw and roller gins?

39. Have saw gins been successful with Indian cottons and, if not, what is the objection to them?

40. Have you experienced any difficulty in obtaining factory labour?

41. Do you find the condition in which raw cotton reaches your factory in any way objectionable and, if so, what remedies would you suggest?

42. Assuming that it were found possible to replace any large quantity of short staple cotton by long staple cotton, would any substantial alteration in your machinery be necessary?

N.B.—The Committee would be obliged by any information you can give them in regard to the general question of long *versus* short staple cotton and also in regard to any experience you have had in handling any new staple cotton.

(b) Spinning and Weaving.

43. What counts are spun in your factory and what is your principal market?

44. Do you find the condition in which cotton reaches your factory in any way objectionable and, if so, what remedies you suggest?

45. What, in your opinion, would be the effect on the cotton market generally if any large proportion of the short staple cotton at present grown in India were replaced by long staple cotton?

N.B.—The Committee would be obliged by any information you can give them in regard to the general question of long *versus* short staple cotton and also in regard to any experience you have had in handling new staple cotton.

V.—GENERAL.

46. Does your experience indicate that buyers in the past have been prepared to encourage the growth of improved cottons by offering a premium for them?

47. Do you consider that the water rates charged have any effect on the cultivator's preference for a particular crop?

48. Do you consider that any changes are called for in the schedule of water rates at present in force?

49. Do you consider that the tenure on which land is held in the tracts of which you have experience in any way affects the extension of cultivation of cotton?

VI.—IRRIGATION.

(For Punjab and North-West Frontier Province witnesses only.)

50. Please state what experience you have had of irrigation in general and in particular of irrigation under canals. Have you any experience of canal irrigation assessment work.

QUESTIONS ISSUED BY THE COMMITTEE.

[Continued.]

51. Has it been your experience that cultivators prefer wheat to cotton as an irrigated crop? If so what is the reason for the preference?

52. (a) What is the critical period in regard to the water-supply in the canals of which you have experience? How would this be affected if there were an increase in the irrigated area under cotton between April and October?

(b) When is cotton watered and what is the volume of water required per acre at each watering?

(c) Please furnish statistics for the channels of which you have had experience showing—

(i) the average flow of the channels month by month throughout the year.

(ii) the average monthly area of each crop irrigated under the channels. It will be sufficient if the average for the last three years is given.

The maximum carrying capacity of the channels should also be stated.

53. (a) Are there any periods during which the supply in the rivers would be sufficient for a large expansion of the area under cotton to utilize which the canals could properly be enlarged with due regard to financial considerations? If so, please give figures for the canals of which you have experience?

(b) How would such an enlargement of the canals affect the area under wheat?

54. (a) To what extent could the duty of water on the canals of which you have experience be improved by equalising the distribution of the supply between the upper and lower outlets on the distributaries?

N.B.—In the Punjab this process is technically known as the "remodelling of outlets."

(b) To what extent could modules be used to effect this purpose?

(c) If the distribution were equalized, what additional irrigated area would accrue? What crops would be grown on this additional area?

55. Does the supply in the rivers increase gradually in spring and decrease gradually in autumn or are both the increase and decrease sudden? In either case what is the effect on the cultivator's preference for a particular crop? Please furnish, if possible, a diagram with statistics illustrating your reply for the canals of which you have experience.

56. (a) In cases in which canals carry a supply for irrigation during the summer months only, would it be possible for the sowings and final waterings of cotton to be carried out by irrigation from wells? Do you know any tracts in which such a combination of irrigation from wells and canals would be feasible in the case of American cotton?

N.B.—American cotton requires watering as follows:—

(i) First watering between March 25th and May 5th.

(ii) Three waterings between the time when the flowers begin to appear which is between July 20th and August 10th and the end of September.

(iii) A fifth and final watering in October.

(b) To what extent do wells exist in the areas commanded by the canals of which you have experience and what steps are required to extend the irrigation under them in those areas?

(c) Have you any experience of tube-wells and do you consider that their use would be valuable in this connexion?

(d) Do you consider that it would be possible sufficiently to improve the canal system by the construction of weirs or in other ways so as to obviate the use of wells?

(e) Can you give an idea of the cost of such an improvement in the canals and the time it would take to carry out as compared with the cost of the construction of the requisite number of wells and time it would take?

57. In case it were found possible to increase the size of canals and consequently the irrigated area under cotton, what addition to gross revenue at present rates for water would you expect? Please illustrate your reply from the statistics furnished in answer to other questions.

58. Can you give a rough estimate of the average area of each crop grown on a holding of 100 acres? How are these areas affected by the water supply and by the necessity for growing a fodder crop and of preserving suitable rotations of crop? Would any proposal you have put forward bring about an alteration in these areas?

59. Have you any experience in regard to the lining of canals? Do you consider it a practicable measure?

60. Can you give a rough estimate of the probable cost of lining canals in terms of acreage irrigated? How does this compare with the acreage rates of cost of the canals in their present condition?

61. If it should prove desirable to enlarge a canal, could this be carried out in conjunction with lining? How would you propose to provide for the existing irrigation whilst the work of enlargement and lining was being carried out?

62. What effect would the lining of canals have on seepage problems and the rise in the subsoil water table? To what extent would the expenditure involved be justified on these grounds?

63. To what extent would the lining of canals improve the supply (a) in the summer months, (b) in the winter months? Would the expenditure involved be justified by the improvement, if any, effected under this head?

64. Do you consider that the water rates charged have any effect on the cultivator's preference for a particular crop? Do you consider that any changes are called for in the schedule of water rates?

VI.—IRRIGATION.

(For witness from Provinces other than the Punjab and North-West Frontier Province.)

65. Please state what experience you have had of irrigation in general and in particular of irrigation under canals. Have you any experience of canal irrigation assessment work?

66. When is cotton watered and what is the volume of water required per acre at each watering?

67. Has it been your experience that cultivators prefer wheat to cotton as an irrigated crop? If so, what is the reason for the preference?

68. Does the supply in the rivers increase gradually in spring and decrease gradually in autumn or are both the increase and the decrease sudden? In either case what is the effect on the cultivator's preference for a particular crop? Please furnish, if possible, a diagram with statistics illustrating your reply from the canals of which you have experience?

United Provinces.]

Mr. F. H. VICK.

69. (a) To what extent do wells exist in the areas commanded by the canals of which you have experience and what steps are required to extend the irrigation under them in those areas ?

(b) Have you any experience of tube wells and do you consider that their use would be valuable in this connexion ?

70. Do you consider the existing water rates charged for cotton suitable ? If you can give statistics to explain your answer, please do so.

71. Can you give a rough estimate of the average area of each crop grown on a holding of 100 acres ? How are these areas affected by the water supply, the necessity for growing a fodder crop and of preserving suitable rotations of crops. Would any proposals you have put forward bring about an alteration in these areas ?

72. Do you consider that sufficient water is available for a considerable increase in the area of cotton and, if so, why is a larger area not irrigated ?

73. Is it your experience that cultivators prefer *deshi* cotton to American cotton ? If so, can you explain their reasons for the preference ?

74. Is it your experience that the canal regulations create any difficulties in regard to the irrigation of American cotton ?

I.—United Provinces.

Mr. F. H. VICK, M.I.Mech.E., Agricultural Engineer, United Provinces.

EXAMINED AT CAWNPORE, NOVEMBER 1ST, 1917.

Written statement.

VI.—IRRIGATION.

3041. (65) Experience.—My experience of irrigation is only small and relates to methods of lift irrigation. I have no direct experience of irrigation under canals nor of canal irrigation assessment work.

3042. (69) Well and tube wells.—In a great many villages now regularly irrigated by canals, the old wells have gone out of use and would, in most cases, require cleaning out and repairing, possibly rebuilding before being of any use for irrigation purposes. Cultivators naturally will not resort to lift irrigation from wells, costing them from Rs. 10 to Rs. 20 per acre per crop, when they can get a gravity flow from canal minors, which costs them from Rs. 3 to Rs. 5 per acre. The matter is thus a purely question of cost, with the cultivator. Regarding the steps that could be taken to extend irrigation by wells in areas commanded by canals the only effective means would be :—

- (1) Entirely to cut off the canal supply to particular villages.
- (2) To raise the canal flow rates to equal the cost of lift irrigation from wells.
- (3) To lower the cost of lift irrigation from wells so that it shall not exceed the present canal flow rates.

Nos. 1 and 2 are too drastic in nature to be of any use, even were they of economic value, which they are not. They can therefore be dismissed. No. 3 then remains as the only practical method that can be adopted to get well lift irrigation to compete with canal flow watering. This matter of irrigation from wells, to supplement canal irrigation, I consider as an extremely important one, and one which will have to be looked into closely in the near future. There are many villages in canal commanded areas which either on account of being situated at the tail end of a minor where water is not available, or else being at a little higher level than surrounding irrigated villages, get no canal irrigation at all. Such villages can at present only irrigate, from wells, a small fraction of their total area and thus compare very unfavourably from a point of view of productivity with adjacent canal irrigated villages.

(2) At present canal flow irrigation is looked to entirely by the Irrigation Branch of the Public Works Department, whilst methods of irrigation by lifting are being developed by the engineering branch of the Agricultural Department. In my opinion, if different irrigation methods are to remain controlled by separate departments, then very much closer co-operation between such departments is necessary than obtains at present, if the best results are to be attained.

(3) Regarding lift irrigation from wells, the old ways of raising water by bullock and *charsa*, and by *dhenkli*, are getting more expensive yearly, owing to increased cost of labour and of bullocks, and more up-to-date methods will have to be resorted to on a large scale in the future. The Agricultural Department has put down many centrifugal pumps and power units during the past few years and has proved that such plant in suitable cases can irrigate land far more cheaply than the old way by *charsa*. The difficulty is that most of the ordinary *pukka* wells of the Province will not in their present condition yield enough water to make pumping profitable. The chief factors governing the cost of such irrigation are :—

- (1) The cost of running the power unit.
- (2) The quantity of water to be lifted per unit of time.
- (3) The head against which raised.

Considering No. 1, very large areas of land could be irrigated that now have no efficient means of watering, if hydro-electric schemes were developed at the larger canal falls and the power given free, or else at very low rates for running centrifugal pumps erected on tube wells. Such schemes would go far to reduce the cost of lift irrigation to that of flow.

(4) The areas in which co-operation between the Irrigation and Agricultural Departments is required on the lines suggested above, are mostly in the west and south-west of the Province and since these are the cotton growing parts, such co-operation, resulting in large areas being given efficient irrigation, would directly influence the area under cotton.

(5) I have experience of tube-wells, having put down many in various districts of this province. I consider that their use in greatly increased numbers would be very valuable in connexion with the increase of the area

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[Continued.]

under cotton. Speaking generally the cotton growing districts are the most suitable parts of the province for tube-wells.

(6) I have tube-wells giving 40,000 gallons per hour as a constant yield and capable of protecting fully 300 acres round each such well and I firmly believe that in the near future I shall be able to rely on a yield of 70,000 to 1,00,000 gallons per hour from a single tube well and to protect fully by irrigation about 600 to 800 acres. The province is fortunately provided with an inexhaustible underground storage of water and it only remains for the engineer to make use of such a great natural advantage.

(7) For purposes of comparison I may mention that the ordinary *pukka* or *kachha* well of this Province yields from 1,000 to 4,000 gallons per hour.

3043. (72) Adequacy of supply to increase in area under cotton.—This question is partly answered above. Talking of this Province, there is no doubt that if underground storage is taken into account, and there is no reason why it should not be, there is sufficient water for a considerable increase in the area of cotton. The development of irrigation by pumping from wells in this Province is not yet far advanced, it only having been started four years ago and the past two or three years having been against rapid progress owing to the difficulty in obtaining plant and the very high prices existing. When power pumping has been greatly developed in the Province, and such development seems to me to be certain, then there will be larger areas irrigated for cotton.

(2) In my opinion it is the duty of Government to take in hand power pumping schemes on a large scale and to make such schemes self-supporting by charging water rates, as is done for canal water.

Mr. F. H. VICK called and examined.

3044. (Mr. Henderson.) In the case of irrigation by tube-wells, if the depth from ground level to subsoil water level is within 25 feet, the cost of irrigation works out to Re. 1 per acre for watering.

3045. (President.) The average depth of tube-well borings from ground level is 200 feet in the United Provinces. Thus if it is 25 feet from ground level to water-level, the tube-well will have 175 feet depth of water in it.

3046. (Mr. Roberts.) I would advocate a general survey of the possible tracts where tube-wells would be feasible. There are parts of the Meerut Division which have practically no irrigation facilities at all, are neither served by canals nor have *pukka* wells for lift irrigation, owing to the difficulty in making good wells in the sandy subsoils. I will furnish figures for those areas where tube-wells or lift is the only feasible form of irrigation. At present we are held up by difficulties in getting materials.

3047. (Mr. Ashton.) The rate of Re. 1 per acre is for each watering and not for the crop. Tube-wells are put down by the Agricultural Engineer and made over to the *zamindars*. I consider them a paying proposition for Government to run, but a big staff would be required as in the case of the Irrigation Department. The Province will be mapped out and divided into districts. Power is at present running to waste on the canal falls. It might be utilised by means of hydro-electric schemes. It might be possible for tube-wells supplied with power from hydro-electric schemes on canal falls to irrigate certain areas on the upper reaches of canals at present irrigated by flow from canals, the water thus saved in the canals being used on lower reaches at present unirrigated, such reaches being outside the range of hydro-electric scheme and being unsuitable for tube-wells. It would not pay to put tubes down for just one watering before the rains. There is need of co-operation between the Agricultural Engineer and the Irrigation Department.

3048. (President.) Tube-wells form much the biggest part of my work. The United Provinces' Irrigation Department about fifteen years ago made experiments in the matter of lift irrigation from ordinary *pukka* wells (not tube-wells) by means of engine and pump. The experiments were not successful, as wrong types of plants were chosen, the matter being in the hands of a Civil Engineer instead of a Mechanical Engineer.

3049. (Mr. Wadia.) It is a matter for the Irrigation Department alone to decide whether canal water can be given in certain areas at specific times. However, as far as one outside the Irrigation Department can see, water will be available from the big canals through May. These main canals are fed from rivers rising in the snows and they thus get an increased supply of water in May through the melting of the snows.

Supplementary written statement submitted by Mr. F. H. Vick.

3050. Preamble.—I submit some points of additional information required by the Committee. I have delayed the matter for some time as I wished to make new tests on this season's *rabt* of the cost of irrigation by tube-wells.

3051. *Irrigation by tube-wells as a supplement to canal-flow irrigation.*—I enclose, as promised, a copy of part of a note put up by me to the Irrigation Department in April last year on the matter of irrigation by tube-wells to supplement canal-flow irrigation. The forepart of the note was on the tube-well as a means of draining water-logged areas. Where the ordinary water-level is high and canal irrigation is resorted to, the land often becomes water-logged and the crops suffer badly. With a well arranged scheme of canal-flow irrigation supplemented by lift irrigation from tube-wells, this water-logging could in a great measure be overcome if the canal water were mostly used on areas where the ordinary subsoil water-level was low, and lift irrigation from tube-wells on parts where the water-level was high. The tube-wells would be drawing water from the subsoil and distributing it on the land surface for irrigation of crops and they would be certain to exercise an ameliorating effect on the surrounding country as regards water-logging, whereas canal-flow irrigation has exactly the opposite effect, that of increasing the water-logging.

(2) As I point out also, in the note, immense power is usually available at canal falls especially on the larger canals and on the higher reaches of such. On the Ganges Canal alone, some 50,000 horse power is available, which would be sufficient for some 2,000 tube-wells irrigating 600,000 acres at least. The tube-well pumps would be electrically driven by energy generated at the canal falls and I would point out that such an arrangement is the very best for showing high efficiency and cheap irrigation.

3052. *Areas suitable for cotton growing under tube-wells.*—Regarding areas suitable for cotton growing provided tube-wells were installed for irrigation, I am unable to give much detailed information on this without a very close investigation entailing two or three months on special duty. I know there are large areas in Muttra and Agra Districts which are quite suitable for cotton growing but which have nearly gone out of

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[Continued.]

cultivation owing to there being no irrigation facilities. I have come across many such areas in the course of my touring. It would need detailed investigation both as to area and tube-well possibilities before definite figures of area could be given. I enclose a plan* of a block of villages in Meerut District where there are no irrigation facilities at all. There is no canal irrigation and the subsoil being sand to a great depth the construction of good ordinary *pukka* wells is rendered difficult. I am just starting to put down a couple of tube-wells in one of the villages of this block and will shortly be able to give more information if such is required. The area of this block is about 50,000 acres and it is right in the centre of the cotton growing tracts. I think it would be quite possible to come to some understanding with the cultivators in this tract in the matter of the growing of long-staple cotton if a certain number of tube-wells were given them for irrigation. The growing of certain crops is, however, more a matter for a Deputy Director of Agriculture to arrange than for me, but if there is any prospect of a grant being given, I will go into the matter with such an officer, and try in collaboration with him to put up definite proposals and figures to the Cotton Committee.

3053. *Cost of irrigation by tube-wells.*—I have found from fresh tests this season that the cost of irrigation by tube-wells comes within Rs. 2 per acre per watering, if the depth from ground level to ordinary subsoil water level comes within 25 feet. This is for running expenses only, depreciation and interest on capital outlay not being reckoned in. I do not consider the above as a final figure as I expect to get much larger capacity tube-wells in the near future and the greater the yield from a single tube-well the cheaper will be the cost of irrigation per unit area. The cost too would, of course, be very greatly reduced if electrical energy were available from canals falls as outlined in the earlier part of this note.

ANNEXURE.

Extract from Note by United Provinces Agricultural Engineer on Mr. Molony's suggested scheme of tube-wells for remedying the effects of percolation from Agra Canals, contained in semi-official No. 226, dated the 13th April 1917, to Chief Engineer and Secretary to Government, United Provinces, Public Works Department, Irrigation Branch.

In the foregoing part of this note, I have considered the matter solely from the point of view of the Agra Canal, Mr. Molony's note especially referring to this. I will now remark on the possibilities of development of power in other and more suitable parts of the Province.

Some of the bigger canal systems embrace falls of magnitude which are capable of supplying almost unlimited power for pumping schemes. Take, for instance, the Ganges Canal between the headworks and Meerut, where there are some eight or ten falls. Allowing, at an estimate, 6,000 cusecs of water at ten feet head and an efficiency with up-to-date turbines of 75 per cent. there is some 5,000 H. P. available at every fall, or a total of 50,000 H. P. for the ten falls.

I am not aware if there are water-logged areas, which cannot be drained by gravity, in the country along the Ganges Canal, north of Meerut. If there are such spots, they might be unwatered by pumping from tube-wells, the pumps being driven electrically, by power developed at canal falls. Such a scheme would only be profitable if worked on a big scale.

The power developed at canal falls might be very profitably used for working tube-wells for irrigation in parts not commanded by the canals. The electrical energy could very easily be carried 20 to 240 miles if necessary, for distribution to the pumping units. Allowing 25 H. P. for each unit, some 2,000 tube-wells each irrigating 300 acres, would be possible, making a total of 600,000 acres of additional irrigated areas and irrigated without drawing at all on the canal supply, a very important point. The cost of tube-well would be about Rs. 3,000 per unit (capacity two cusecs each) in normal times if constructed in big number with suitable plant.

To make a start in the direction indicated, the power developed at Bahadurabad for the construction works at Bhimgoda might, after the completion of that work, be used to work tube-wells, to irrigate a little of the tract of country west and north-west of Roorkee, which is not commanded by the canal, and would benefit greatly from proper irrigation.

Development of power at canal falls has been proposed on many occasions, but mostly for industrial purposes and for this the point against the scheme has been that the canal would probably be closed for six weeks or two months in July and August during the rains, for annual repairs to the canal works, and that then power would not be available, and industrial concerns be obliged to close down for the period or else go to the expense of installing steam plant as an alternative source of power supply. Such a closure would not adversely affect the tube-well scheme as, when the canal was shut off during good rains, the tube-wells would not be required to run for irrigation.

Where the demand for water for irrigation from a canal was greater than the supply and the canal contained falls capable of power development on a large scale, it would be a feasible and profitable arrangement to sink tube-wells in big numbers and work them electrically. Such tube-wells could irrigate large areas at present irrigated from the canal and the canal water thus saved could be used in parts not before irrigated and which were outside the range of electric power for tube-wells. In general, it would be upper reaches of canals that contain falls for power development. Taking again the instance of the Ganges Canal, no water need be abstracted from the canal for irrigation north of say Muzaffarnagar or Meerut. The area at present irrigated could be quite as well served by tube-wells worked by power from the falls. At a moderate lift, say twenty to thirty feet, the running costs for such irrigation pumps would not come to more than eight annas per acre per watering, if run by electric motors fed with current generated at canal falls.

The enormous possibilities of tube-wells, as a means of giving proper irrigation to the vast alluvial plains of Upper India, are at present realized by few, but I have no doubt that they will be resorted to very largely in the future and that they will be a factor of great economic importance. The tube-well at present is comparatively new to India but a constant flow of about two cusecs each can already be obtained from them. Later on, with development and better and bigger plant for sinking, I am confident that flows of six to eight cusecs will be obtained, and something like 1,000 to 1,200 acres be irrigated from each tube-well. The matter is well worth the close study of the Irrigation Department.

* Published in separate volume of maps and plans.

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Mr. A. C. H. LAURIE.

Mr. A. C. H. LAURIE, Superintending Engineer, Second Circle, Agra.

EXAMINED AT CAWNPORE, NOVEMBER 2ND, 1917.

Written statement.

3054. *Preamble*.—In the note below I have recorded my opinions only on those points which I felt I could give an opinion on with confidence. I may mention that I have had canal experience extending over 25 years on the Upper and Lower Ganges, Eastern Jumna, Agra and Betwa canals, have a good knowledge of the vernacular, and am interested in the people and their crops.

I.—AGRICULTURAL EXPERIENCE.

(a) "*Deshi*" short-staple cotton.

3055. (7) Conditions affecting increase in area.—The yield under *deshi* short-staple cotton fluctuates largely. The chief contributing causes are the rainfall of the early *kharif* season—May and June—and market prices. The factors limiting the increase under cotton in addition to the rainfall and prices are chiefly economic. The ordinary cultivator of limited means cannot procure sufficient manure, and depends upon frequent ploughings and rotation of his crops to obtain the maximum return from his holding. A cotton crop is usually followed by barley, sometimes pure but generally mixed with peas or is left fallow during the following *rabi* and sown with sugarcane on the following *kharif*. The latter requires a certain quantity of manure, means of irrigation, and some capital to meet the costs of cultivation. Another contributing cause is that the cultivator usually reserves a part of his holding (when a water-supply is assured) for wheat, from which he pays his land rent. Cotton prevents wheat being sown on account of the want of time in which to prepare the land between the cotton being cut and wheat being sown. With a better supply of manure (to take the place of ploughings) wheat could follow cotton and the area of cotton be increased.

(c) *Exotic* cotton.

3056. (21) Varieties.—American cotton is the variety with which I am acquainted.

3057. (25) Conditions affecting increase in area.—The principal factor limiting the area put under American cotton is that it is later in coming to maturity than *deshi* cotton, and thereby can seldom or ever be followed by a *rabi* crop (as mentioned previously). It is also not so hardy as the *deshi* variety during the earlier and later stages of its growth, requiring more water and labour in the former and being more susceptible to climatic vagaries in the later stage.

V.—GENERAL.

3058. (47) Effect of water rates.—The water rates charged only affect the cultivators' preference for a particular crop to a very slight extent as the canal water rates are extremely low.

3059. (48) Desirability of alteration in water rates.—In spite of the lowness of the canal water rates, which are one quarter what other means of irrigation cost, and the fact that the canal water rates have not been changed in the past twenty years while prices of agricultural produce have doubled, I am not prepared to recommend raising the rates. I am, however, emphatically of opinion no reduction should be made.

VI.—IRRIGATION.

3060. (65) Experience.—Please see preamble to this note. I have had no experience of other than canal irrigations. I have experience of canal assessment work.

3061. (66) Watering of cotton.—Cotton waterings for sowing (*paleo*) are usually begun about 15th to 20th May. The depth of water taken for watering is, I should say, about four inches to six inches or roughly, 20,000 cubic feet or 120,000 gallons.

3062. (67) Cotton *versus* wheat.—Cultivators prefer wheat to cotton because wheat cannot do without watering and the difference in produce between an irrigated and unirrigated crop is far greater in the case of wheat than in that of cotton as a general rule. Also the climatic influences are a bigger factor in the case of cotton, a monsoon crop, than wheat, a cold weather crop.

3063. (68) Fluctuations in river-supplies and their effect.—The fluctuations of the river-supply are exhibited in diagram no. 1 (Annexure IV)* accompanying this note. The fluctuations would have been better appreciated if shown in volumes instead of gauges (the volume varies parabolically, the variation increasing more rapidly than the gauge. Due to not having a discharge table for Raiwala gango and the time to get it before submitting this note, I had to fall back on a diagram of gauges). I should mention that Raiwala is situated six or eight miles above Hardwar and represents the total river-supply available for the needs of the Upper and Lower Ganges canals at all seasons of the year, and in unusually dry hot seasons also contributes a considerable proportion of the supply of the Agra canal (it is passed down to the Agra canal through the Upper Ganges canal, Jaui escape and Hindim Nadi).

(2) As will be seen from the diagram, the increase is fairly rapid in May and June and decrease likewise in October to December.

3064. (69) Wells and tube-wells.—I have not information at hand on the extent of wells in the area commanded by the Lower Ganges Canal. Generally speaking canals are not carried into areas served by wells for two reasons: (1) *kachha* wells (which are the usual form of agricultural well) are actually affected by the rise in spring level which the pressure of canals induces, and (2) it is not canal policy to displace well-irrigation. The only tracts which I can think of in my circle (the Doab from Aligarh in the north-west to Fatehpur in the south-east where any considerable number of agricultural wells are worked are Nini-Kalinadi doab, Aligarh district, Bagar-Kalinadi doab, Etah and Farrukhabad districts, and Sirsa-Singar doab, Manipuri and Etawah districts, I have no suggestions to offer as to steps required to extend irrigation from wells.

(2) I have no experience of tube-wells.

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[Continued.]

3065. (70) Suitability of existing water rates.—I consider the existing water rates charged for cotton suitable. I find it difficult to quote statistics to support my opinion. From diagram No. 2, (Annexure V)* which shows the areas of cotton† irrigated, canal-supplies during May and June, and rainfall during the same months it will be seen that the area of cotton irrigated varies inversely as the rainfall. I had expected to find the variation more influenced by the rainfall of May which is the more critical of the two months concerned. The fact is the cultivator is always sanguine of timely rainfall and holds off from taking canal-water as long as he can.

3066. (72) Adequacy of supplies to increase in area under cotton.—Under normal conditions I think there is sufficient water not utilised to enable an increased area of cotton being sown with canal-irrigation. This will be seen from Annexure I to this note. I cannot give adequate reasons why a larger area is not irrigated.

3067. (73) *Deshi versus American cotton*.—It is my experience that the cultivators prefer *deshi* cotton to American. For reasons affecting the cultivators' choice please see answer to Question 25. (paragraph 3057).

3068. (74) Effect of canal regulations.—I do not consider that the canal regulations create any difficulties in regard to the irrigation of American cotton. On the contrary, the Canal Department is put to considerable trouble in meeting demands made on behalf of American cotton. I refer to temporary outlets which are usually asked for to encourage the sowing of American cotton. The Lower Ganges canal irrigates only half the area in *kharij* that it does in the *rabi* season. The numbers, positions, and signs of permanent outlets which are provided have been so arranged as to secure the maximum area of *rabi* irrigation in the tracts commanded by the channels with due regard to the supplies available and ensuring that a sufficiency of water reaches the tails of the channels. Therefore the permanent outlets should suffice for more than all possible *kharij* needs. I consider the practice of giving temporary outlets to encourage American cotton sowings should be discouraged. They have been so given for many years past, and if American cotton is to take on with the Indian cultivator, he will irrigate it from the permanent outlets at his command. The better plan is to afford preferential treatment to cultivators who are keen on sowing American cotton by running selected channels for longer periods, as was done in the past *kharij*; I have not got figures to prove but think it gave satisfactory results.

* Published in separate volume of maps and plans.

† In Annexure II will be found details of areas of cotton irrigated by Districts and Canal Divisions.

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Mr. A. C. H. LAURIE,

[Continued.]

ANNEXURE I.
Statement showing average volumes, entered, escaped and utilized in the Lower Ganges canal for the months of January to May and November and December for the years 1907—16.

Years.	1907.			1908.			1909.			1910.			1911.			REMARKS.
Montons.	Mean discharge.			Mean discharge.			Mean discharge.			Mean discharge.			Mean discharge.			
	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	
November	3,098	370	3,328	4,537	1,078	3,459	3,753	1,048	2,705	5,135	2,467	2,668	4,286	Closed.	2,802	
December	3,144	267	2,877	3,472	580	2,892	4,366	938	3,508	5,370	1,065	4,305	4,286	1,484	2,802	
January	3,351	755	2,596	2,694	201	2,493	3,325	547	2,778	4,490	1,602	2,888	3,021	2,087	934	
February	3,375	1,355	2,020	3,017	404	2,613	2,877	442	2,435	3,640	735	2,905	5,047	675	4,372	
March	3,168	1,327	1,941	2,087	231	1,856	2,481	332	2,149	2,610	635	1,875	3,283	1,954	1,329	
April	3,424	1,114	2,310	2,046	242	1,804	2,745	815	1,431	2,767	567	2,200	4,456	942	3,514	
May	4,898	1,179*	3,719	2,846	627*	2,219	3,745	1,140*	2,605	4,059	868*	3,191	5,131	666*	4,465	
June	5,476	1,120*	4,356	4,752	896*	3,866	5,124	2,080*	3,044	3,790	1,322*	2,468	5,375	578*	4,797	
	1912.			1913.			1914.			1915.			1916.			Note—Escaped includes loss from percolation which varies from 5 to 900 cuases in main canal alone. With reference to note above from a study of the figures asterisked will be seen that except in May and June, 1916, and May, 1916, there was more than sufficient water in the canal than required for the needs of irrigation.
	Mean discharge.			Mean discharge.			Mean discharge.			Mean discharge.			Mean discharge.			
	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	At head.	Escaped.	Utilized.	
November	5,804	2,496	3,308	4,571	463	4,108	6,073	1,475	4,598	5,326	2,298	3,028	4,755	1,550	3,205	
December	4,310	862	3,448	3,584	684	2,904	4,878	460	4,418	4,279	507	3,772	5,061	767	4,291	
January	3,711	1,191	2,520	3,383	679	2,704	2,963	432	2,631	4,088	458	4,230	3,569	535	3,034	
February	4,999	1,051	3,948	2,992	774	2,188	2,724	330	2,394	3,242	2,237	1,005	3,178	302	2,876	
March	3,263	1,023	2,240	4,239	1,461	2,778	3,072	629	2,443	4,222	2,182	2,040	2,574	292	2,282	
April	3,658	658	3,000	3,299	504	2,795	4,109	635	3,474	4,722	433	4,289	2,591	226	2,365	
May	4,579	782*	3,797	5,094	1,191*	3,900	6,180	910*	5,270	6,120	545	5,679	2,793	458	2,335	
June	5,640	800*	4,740	6,101	1,329*	4,775	6,079	1,014*	5,065	5,981	594	5,387	5,239	1,790*	3,449	

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Mr. A. C. H. LAURIE.

[Continued.]

II.—Statement showing by Canal Divisions and Civil Districts the areas of cotton irrigated in the Second Circle during the years 1907—16—contd.

Districts.	Etawah division (Including Ghatampur distributary) Lower Ganges canal.										REMARKS.
	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	
Average rainfall of division in inches for May and June—											
May	0 21	0 06	..	0 01	..	..	0 00	0 83	0 08	..	
June	0 24	0 38	2 86	4 37	0 83	0 47	2 90	1 41	0 40	3 05	
1. Bulandshahr . .	..	..	..	..	..	..	..	..	..	..	N.B.—All areas are in acres.
2. Aligarh . . . .	..	..	..	..	..	..	..	..	..	..
3. Etah . . . . .	..	..	..	..	..	..	..	..	..	..
4. Farrukhabad . .	..	..	..	..	..	..	..	..	..	..
5. Mainpuri	10,248	7,152	7,022	5,503	10,554	11,477	12,883	7,443	3,630	5,881	
6. Cawnpore	9,095	9,302	5,294	5,060	8,381	0,205	13,450	12,821	3,024	2,788	
	5,662*	7,200*	4,368*	5,073*	6,888*	6,744*	11,715*	15,456*	5,623*	2,036*	* These figures are for Ghatampur distributary
TOTAL	14,757	16,571	0,002	10,133	15,209	10,009	25,165	28,277	0,247	4,824	
7. Etawah	20,522	14,258	11,312	10,406	17,240	22,230	20,021	28,166	6,601	8,185	
8. Fatehpur	868*	1,137*	700*	588*	1,075*	1,225*	1,664*	2,340*	820*	255*	* Ghatampur distributary.
9. Allahabad . . . .	..	..	..	..	..	..	..	..	..	..
	39,865	30,802	23,628	21,050	36,181	42,072	55,954	48,430	13,951	10,854	
	6,530*	8,346*	5,128*	5,061*	7,903*	7,060*	13,370*	17,706*	6,443*	2,201*	* Ghatampur distributary.
TOTAL	46,305	30,148	28,756	26,720	44,144	50,941	69,333	66,226	20,394	10,145	
Average 41,120 acres.											
Fatehpur division, Lower Ganges canal.											
Average rainfall of division in inches for May and June—											
May	0 04	0 01	0 11	0 16	0 01	0 05	1 32	0 55	..	..
June	1 03	0 03	7 19	6 14	1 82	1 07	5 20	0 37	3 52	8 15	
1. Bulandshahr . .	..	..	..	..	..	..	..	..	..	..
2. Aligarh . . . .	..	..	..	..	..	..	..	..	..	..
3. Etah . . . . .	..	..	..	..	..	..	..	..	..	..
4. Farrukhabad . .	..	..	..	..	..	..	..	..	..	..
5. Mainpuri . . . .	..	..	..	..	..	..	..	..	..	..
6. Cawnpore	2,420	2,030	097	830	2,470	2,418	2,807	3,830	1,431	367	
7. Etawah . . . . .	..	..	..	..	..	..	..	..	..	..
8. Fatehpur	5,160	3,108	1,264	1,280	5,466	3,670	6,969	6,110	2,097	347	
9. Allahabad	537	83	12	27	251	230	540	160	10	23	
TOTAL	8,117	5,221	2,273	2,137	8,217	6,318	10,406	10,118	3,547	737	
Average 5,700 acres.											

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[Continued.]

II.—Statement showing by Canal Divisions and Civil Districts the areas of cotton irrigated in the Second Circle during the years 1907—16—contd.

District.	Bhognipur division, Lower Ganges canal.										REMARKS.
	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	
Average rainfall of division in inches for May and June—											
May	0.66	0.64	0.61	0.64	..	0.11	0.74	0.63	0.61	..	
June	0.37	0.66	0.51	0.32	0.62	0.66	2.32	1.37	1.32	3.06	
1. Bulandshahr . .	..	..	..	..	..	..	..	..	..	..	N.B.—All areas are in acres.
2. Aligarh . . . .	..	..	..	..	..	..	..	..	..	..
3. Etah . . . . .	..	..	..	..	..	..	..	..	..	..
4. Farrukhabad . .	..	..	..	..	..	..	..	..	..	..
5. Mainpuri	7,196	4,466	4,673	3,854	7,048	5,963	6,593	8,804	2,799	4,658	
6. Cawnpore	14,690	16,026	5,371	8,163	11,396	9,325	17,162	16,718	7,675	4,448	
7. Etawah	20,436	18,773	6,836	12,262	26,065	21,776	28,562	36,540	16,155	7,348	
8. Fatehpur . . . .	..	..	..	..	..	..	..	..	..	..
9. Allahabad . . . .	..	..	..	..	..	..	..	..	..	..
TOTAL	42,220	38,205	19,280	24,270	39,112	37,061	52,237	50,062	20,536	16,754	
Average 34,577 acres.											
Total, Lower Ganges canal.											
Average rainfall of division in inches for May and June—											
May	0.19	0.14	0.01	0.22	0.006	0.16	1.75	0.70	0.10	0.03	
June	0.28	0.07	3.05	3.67	0.65	1.03	4.03	1.02	1.44	4.35	
TOTAL	0.46	1.11	3.06	4.19	0.90	1.15	5.78	1.72	1.54	4.41	
1. Bulandshahr . .	..	..	..	..	..	..	..	..	..	..
2. Aligarh . . . . .	..	..	..	..	..	..	13	11	..	..
3. Etah	13,613	12,028	9,746	6,791	17,621	21,118	25,966	23,476	6,252	7,043	
4. Farrukhabad . .	6,684	5,728	4,666	6,891	9,600	11,764	14,485	16,840	3,854	3,735	
5. Mainpuri	28,582	19,867	16,516	16,664	20,391	39,651	35,977	34,409	11,447	18,135	
6. Cawnpore	45,330	39,216	19,243	22,722	37,474	36,056	61,657	64,446	22,610	11,364	
7. Etawah	41,593	33,333	21,363	22,062	38,352	44,066	56,128	50,884	16,051	15,753	
8. Fatehpur	6,628	4,245	2,024	1,868	6,541	4,865	8,033	8,459	2,917	662	
9. Allahabad	537	83	12	27	281	236	546	169	19	23	
TOTAL	1,45,368	1,14,443	72,664	70,665	1,36,560	1,46,356	2,05,733	2,07,778	64,850	57,255	

ANNEXURE III.

Schedule of Cotton Rates.

Canal.	Rate.		Notification.	Rate.		Notification.
	Rs. A. P.	Rs. A. P.		Rs. A. P.	Rs. A. P.	
Upper Ganges canal .	2 4 0	1 8 0	N9841 of 10th April, 1873	3 0 0	1 8 0	N3376 of 15th December, 1892.
Eastern Jumna canal }	2 4 0	1 8 0		3 0 0	1 8 0	
Lower Ganges canal .	..	..		3 0 0	1 8 0	
Agra canal	3 0 0	1 8 0	N1232 of 19th November, 1874.	..	..	N940 of 22nd October, 1878.
Upper Ganges canal	2 0 0	1 0 0	N1692—96 of 29th March, 1905.	..	..	....
Eastern Jumna canal	2 0 0	1 0 0		..	..	....
Lower Ganges canal	2 0 0	1 0 0		..	..	....
Agra canal	2 0 0	2 0 0	N1695 of 29th March, 1905.	3 0 0	1 8 0	N544 of 1st April, 1910. Punjab only.

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[Continued]

Mr. A. C. H. LAURIE called and examined.

3069. (Mr. Ashton.) Speaking generally, the system of canal irrigation in the United Provinces is, I believe, much the same as in the Punjab, except that while in the Punjab, distributaries are run by rotational turns only occasionally when there is not sufficient supply for all of them, in the United Provinces distributaries run usually by rotation and only in the sowing season are supplies ample to run them all simultaneously. In designing channels, a fixed percentage of the culturable commanded area is taken, less the area which is protected by *pukka* wells. The percentage is usually forty to fifty, forty per cent. being taken for the *rabi* demand. This applies particularly to the Lower Ganges Canal where the channels are designed with reference to the *rabi* area which is the bigger of the two. The *rabi* irrigation is twice that of the *kharij*. We allow about one cusec for 100 to 120 acres of *rabi* irrigation. A large proportion of the area is usually sown under rainfall. In the Ganges system, as large a proportion of the area as 25 per cent. might be unculturable.

3070. As to whether it would be possible to increase the cotton cultivation and whether the expense would be worth it, I can only say that we have not got much water to spare for it. There is no water to spare for any increase in the canal irrigated area at the expense of the well area. The province is at the end of its tether. Our channels are designed for alternate running and not for constant running. American cotton is sown earlier than *deshi* and takes longer to mature.

3071. As a rule, the Ganges river has very little water at the beginning of April. At the end of April, the snows begin to melt and the water rises and there is sufficient water available for all present needs from the end of April onwards. The cultivator is engrossed in *rabi* harvest operations in April, on account of which there is not much demand for water in that month. February and March are the months in which the supplies are at their lowest.

3072. The loss from percolation is one cusec per mile in the branches and on the main canal, which is less impervious, it varies from five to ten cusecs per mile. The loss by percolation is very heavy in the main canal. An average loss of 500 cusecs would be probably the correct figure.

3073. There is some room for expansion of irrigation but the question is whether it would be better to expand cotton on the Lower Ganges or sugar on the Upper Ganges. About 1000 cusecs might be put down as available for expansion of irrigation in the months of May and June.

3074. This year we concentrated water on certain channels for the cultivation of American cotton during May but the reports show that there has been practically no expansion. It was found that other *kharij* crops were irrigated from temporary outlets as much as American cotton. Concentration on certain channels, in my opinion, (though it is not based on experience) is probably a mistake as it penalizes the persons whose channels are closed. I have not heard any complaints about it. So far as my experience goes, advantage was not taken of the concession to any great extent. The Irrigation Department figures do not differentiate between American and *deshi* cotton. If it is found necessary to continue the concession in order to popularize American cotton, the penalization of *deshi* cotton involved will lead to difficulties. The penalization of *deshi* cotton would lead to a decrease in the area under it and might not lead to an increase in American. Since the rates for cotton were reduced (from *kharij* 1905), the area under it has gone up. The rates were reduced from Rs. 3 and Rs. 1-8 to Rs. 2 and Re. 1. Since then the area under indigo has gone down and that under cotton up. The lower rate is for lift.

3075. I do not think that it would be a good thing to put a penal rate on catch crops such as peas as the cultivator could not grow anything else in the fields he now grows peas in. He cannot grow wheat after cotton, as there is no time for ploughing. Ninety-five per cent of the area under cotton is followed by peas and *bajra* (barley and peas mixed). Peas can be sown right up to the end of December up to which the cotton pickings can be taken. The American cotton does not get off from the ground early whereas *deshi* does and a catch crop can be sown. I am doubtful if the penalizing of a catch crop would be satisfactory.

3076. The cultivator does not know much about American cotton. He is very conservative. Another point against the adoption of American cotton is that it is much more susceptible to damage by climatic conditions.

3077. The areas in which the subsoil water supply is 20 to 25 feet below the surface would include practically all canal irrigated lands. I have no experience of tube wells and I cannot therefore say whether hydro-electric tube-wells for such areas would be possible. It is questionable whether water could be supplied at commercial rates. Well irrigation costs four times as much as canal irrigation. Canal irrigation competes against the monsoon. If the rates were put up, canal irrigation would diminish. The rate for sugarcane was put to Rs. 10-8 from Rs. 6-10-8 per acre. The area under sugarcane fell considerably and it was decided that the rate was prohibitive. The flow rate is now Rs. 6-10-8 per acre. The note I have submitted represents the general opinion of the Irrigation Department both European and Indian as well as non-official opinion.

3078. I am doubtful about the feasibility of increasing the water supply by building reservoirs on the upper reaches of the Ganges. The slope at Hardwar is 1 in 400. It is not possible to do much with a slope as that. The only way to increase the area irrigated is to remodel the distributaries so as to run on a basis of one week's running to two weeks' closed. I would advocate the factor of discharge being taken as one cusec per eighty to ninety acres irrigation instead of the present practice of one cusec per 100 to 120 acres. They are now designed for one week's running and one week closed. Except for rice and poppy crops, the other crops could stand closure for two weeks. Even poppy might be able to stand it. Remodelling means increasing the discharge. New outlets would not be necessary to any extent as there is difficulty in supplying the needs of existing outlets in the lower reaches of distributaries. We may be able to give new outlets on some existing channels. The irrigation statistics of almost all distributaries show that the intensity of irrigation decreases from head towards tail, due to difficulty in getting sufficient water down to the tails. There has been some re-distribution of outlets to remedy this defect. The outlets at present are about half of cast iron pipes and half of masonry. I have not tried Kennedy gauge outlets. Wilkins modules were tried in the Cawnpore Division but were not a success, I am in favour of Kennedy gauge outlets. There would be less waste if gauge outlets were used.

3079 (Mr. Henderson.)—We have protective canals and productive canals in the United Provinces: In Bundelkhand, the canals are all protective, that is to say they are not looked on as financially remunerative. The Agra canal is productive. The ventages of our outlets are six inches and four inches. For 120 acres of irrigated *rabi* with ordinary good command we should give a six-inch outlet which should discharge

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one cusec with a head of one foot. Out of a total culturable area commanded of 300 acres we should allow a percentage of irrigation of forty in *rabi*, i.e., 120 acres only, for which a six-inch outlet would be sufficient. The proportion of *kharif* is half of *rabi*. There would be no difficulty in supplying water in May except in an unusually dry year such as 1916 when the river supply did not rise till the 29th May at Narora, the head of the Lower Ganges canal. There would be no difficulty in sowing American cotton in May, as indigo would be the only competing crop. No special precautions would be required in my opinion. Some water is at present wasted. If cotton seed were given out to be sown in May, there would be no difficulty in meeting the demand for water. It is not the usual practice to sow wheat after cotton. Peas are sown even later than December. There is therefore no objection to American cotton on the score of lateness so far as peas are concerned. Barley cannot be sown after November; it is usually sown mixed with peas.

3080. (To Mr. Roberts.)—The cultivator depends on the monsoon and this leads to an irregularity in the demand for water for sowing cotton. The sowing of American cotton would lead to a more regular demand for water. I do not believe in the practice of encouraging certain crops by giving temporary outlets. It increases the difficulty of getting water down to the tails. It upsets the régime of the channels. I consider it fundamentally wrong as a permanent policy but have no objection to it as a temporary measure.

3081. American cotton is very susceptible to damage by climate. I have little experience of American cotton grown under irrigation. The produce of the American cotton at Aligarh Farm this year is less than that of *deshi* cotton or Mr. Leake's cotton. My opinion is based on what I have heard from cultivators. American cotton does not allow anything else to be grown with it as *deshi* cotton does, owing to its spreading and dense foliage. The chief crops grown with *deshi* cotton are *urad*, pulses, *til* and *arhar*. *Arhar* could be sown with American cotton but nothing else.

3082. (President.)—The Irrigation Department does not work in very close touch with the Agricultural Department. Mr. Burt consults the Irrigation Department pretty freely, especially the Divisional Officers. There are no regular conferences between Irrigation and Agricultural Officers. I think it would be very helpful to have such conferences. I am of opinion, that the policy of conferences should be developed.

3083. If any system of irrigation by tube-wells were developed on a big scale, it should be under the Agricultural Engineers. The Irrigation Department already has its hands full. Its present duties are as much as it can manage.

Mr. RAJ NARAIN, B.A., C.E., Executive Engineer, Irrigation Branch, Public Works Department, United Provinces.

EXAMINED AT CAWNPORE, NOVEMBER 2ND, 1917.

Written Statement.

VI.—IRRIGATION.

3084. (65) Experience.—I joined the Irrigation Department of the United Provinces in September, 1902, as an Assistant Engineer under training in the Northern division, Upper Ganges canal, at Hardwar, where I worked for about nine months on the Head Works and in the first sub-division. I was then transferred to the Fatehpur division, Lower Ganges canal at Cawnpore. Here I held charge of the first and third sub-divisions for about one year. I was transferred to the Lower division, Agra canal, at Muttra in July, 1904, and to the Anupshahr division, Upper Ganges canal at Meerut, in December, 1904. I was retransferred to the Lower division, Agra canal, in November, 1905, where I remained up till July, 1909. In this period I held charge of the division in 1906, for six months, and charge of the second Sub-division for the remaining period. I was transferred to the Lower division, Eastern Jumna canal, at Delhi in July, 1909, for a short period, and held charge of the division for six weeks. I was transferred in November, 1909, to the Hathras Branch division, Upper Ganges canal, for construction work in the second sub-division, where I worked up till 18th April, 1910. I was then permanently put in charge of the Meerut division, Upper Ganges canal, as Executive Engineer after 6½ years' permanent service. I retained charge of this division for about five years, and in addition to these duties, I worked as Traffic Manager of the Upper and Lower Ganges canals, having my jurisdiction over the whole length of the two canals, from 1910 to 1915. I was transferred to the charge of my present division on 24th March, 1915, and still retain the same charge, with my headquarters at Etawah. I held charge of the Bhognipur division in addition to my own duties in December, 1915.

(2) I have thus gained fifteen years' experience as a Canal Assistant and Executive Engineer in those provinces. My regular duties required the construction and repairs of canals and other irrigation and drainage channels, the distribution and regulation of supplies, the inspection of irrigated areas, and the assessment of canal water-rates.

(3) I am a hereditary *zamindar* of these provinces and had some experience of well irrigation before I joined the profession. After entering the department I gained further experience in irrigation from wells, tanks, *jhils*, and *nadies*.

3085. (66) Watering of cotton.—Operations for sowing *deshi* cotton with canal water are started after the middle of April. Wells and tanks are also used where they exist. To begin with, fields are '*paleoed*' (given a watering) with canal water on any date from the last week of April to the 1st week of June. They cannot be ploughed up without rainfall or previous *paleo*, as they are hard. Single *paleo* is sufficient for soft fields or for those which had wheat, barley, peas or other *rabi* crops. Double *paleo* is necessary for hard soils, fallow land and for those fields which had *arhar* or similar crop, previously. About one-fourth area under cotton is sown after single *paleo* and three-fourths after double *paleo*. The latter is supposed to give better results. After the first *paleo* the field is allowed to dry up for about a week or less, till it acquires semi-dried condition, called *out*. It is then ploughed up. If the second *paleo* is not decided upon, it is sown at once, by scattering seed broadcast and reploughing it to cover the seed with earth. When, however, there is time and necessity for a second *paleo*, the ploughed up field is allowed to bask in the sun for a week or ten days. This is believed to increase the fertility of the field and to act as manure,

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as extraneous matter in the soil gets rotten and is converted into manure. Suspended matter and gorms from the air also get deposited on the field surface in this process, and increase its productive power. After this period the field is *paleoed* again and re-ploughed after partial drying (*oat*) as before. The seed is then immediately thrown over the surface and the field ploughed up again, so that it may get buried below the surface at a safe depth for germination. The seed germinates completely in a week or so. Sowing after *paleo* is started in the middle of May and completed in the middle of June. Then the cultivators await the rainfall for future sowings.

(2) In cotton fields which are sown after single *paleo*, the first watering is given when the plants are about nine inches high, after three weeks from the date of sowing, and in those which are sown after double *paleo*, it is given after a month. The second watering is given when the plants are about 2½ feet high above ground. If the rains do not begin early in July, the second watering is rendered necessary, but a fall of even an inch of rain in the middle of June renders even the first watering unnecessary and rather injurious. A delay of a week or two does not appreciably injure the crop, which picks up wonderfully as soon as the required watering is given. The first watering is given after weeding the crop. It is subsequently weeded three or four inches times before maturing. It is matured with light rainfall, and frequent breaks. It is injured if the field remains under water continuously for more than ten days. The production is better in comparatively dry years and in dry areas. In wet years its produce is greatly reduced and it does not thrive in low-lying lands or depressions. Even in very dry years, more than two waterings are rarely necessary.

(3) In 'flow' fields, about two to three inches or an average of three to five of water is usually given for a first *paleo*. This amounts to about 14,000 cubic feet of water. In 'lift' fields about five inches depth of water is usually considered sufficient for the first *paleo*. In the former, the cultivators generally leave the watercourse open into the field before they retire at night. Next morning, if they find that more than the required quantity of water has run over their field, they drain off the excess into the adjoining field. As a rule, 'lift' irrigation is avoided during the hot weather or *kharij fasl*. The second *paleo* and the first watering are about three inches deep, and the second watering is a little less. On an average the following volume of water is required for sowing and maturing *deshi* cotton crop per acre :—

First <i>paleo</i>	14,000 cubic feet.
Second <i>paleo</i>	11,000 "
First watering	10,000 "
Second watering	Nil (neglected)
TOTAL	35,000 cubic feet.

3086. *Cultivation of American cotton.*—The cultivation of this variety of cotton is not yet properly understood by the ordinary agriculturist. Its fibres are long and fine, and it is in great demand for manufacture of fine cloth. Its cultivation is a more delicate and complex affair than that of the *deshi* cotton. It is sown about fifteen days earlier than the latter, and if sown before 15th May or after 15th June, the results are not very satisfactory. If rain falls before the 15th June, it is sown without *paleo*, and the rain-sown American cotton gives better results than that sown with *paleo*. But as rains do not usually begin till the third week of June, it is sown, as a rule, with one or two *paleo*. In single *paleo*, the field is watered one week before the date of sowing, and in double *paleo* the first watering is given a fortnight before that date. It requires a little more water for its irrigation than *deshi* cotton, and if the irrigation is delayed by a few days, the crop appreciably suffers. Its roots do not go so deep below the surface as those of *deshi* cotton, but they spread out more on all sides. The results that its crop gets damaged if the field remains flooded for more than a single day. It is ruined if water stays there for over five days. Water has therefore to be drained off daily as it rains and the field surface kept as dry as possible. With *deshi* cotton, the crop is not damaged in two or three days, nor is it ruined within ten days. The required quantity of manure and number of weedings are about the same in both cases. *Deshi* cotton crop lasts for a single *fasl*, i.e., from May to October, in which month the field can be again immediately ploughed up and sown with peas, harley, etc. But American cotton lasts a month longer, when the time for sowing such additional crops expires. If required, the American crop unlike the *deshi* variety can remain standing for the next year or two, by trimming branches, which shoot out again, but this practice is discouraged, as it gets injured by insects and its production falls greatly after each *fasl*. No other crop can be sown mixed with American cotton or inside the same field, as is done with *deshi* cotton fields, which contain *arhar* and *til* (sesamum) *mung* (pulse), *urad* (pulse) *palsana* and *kachri*, sown side by side. The first two are not supposed to have an injurious effect by this admixture, *arhar* being sown in rows dividing the field into compartments. The remaining crops have some ill effect on cotton, as they suck up most of the nourishment from the soil, but the cultivators occasionally ignore this fact. In a fertile field the maximum height reached by *deshi* cotton crop is six feet, whereas that by American cotton only five feet. The branches of the former are, however, smaller than those of the latter. In the former case the plants are thin, but in the latter case they spread out well on all sides. The cost of production of the former per acre is Rs. 25, but that of the latter only Rs. 22. The flower and bolls of the *deshi* cotton hang downwards and are consequently not so easily injured by rain as those of the American cotton which either stand upwards or slant in all directions. *Deshi* cotton boll gives 33 to 40 per cent. cotton and 67 to 60 per cent. seed whereas American cotton boll gives only 26 per cent. cotton and 74 per cent. seed, the American seed being bigger than the *deshi* seed, although both the bolls are about equal in size. The yield per acre of good American cotton fields varies from eight to twelve maunds, while that of *deshi* variety varies from six to ten maunds. American cotton, however, sells only Re. 1 per maund dearer than *deshi* variety. The cultivators frequently make mistakes with American cotton crop, e.g., sow it deeper than necessary or fail to water it at the proper time, but they have no such fears with the *deshi* cotton, the production of which they have learnt from their early years.

3087. (73) *Deshi versus American cotton.*—The cultivators prefer *deshi* to American cotton for the following reasons :—

- (1) They think that they know sufficiently about the cultivation of *deshi* crop whereas American cotton is new to them. They hesitate in adopting it.
- (2) They are tied down to certain dates in sowing American cotton seed, whereas they have greater liberty of action with *deshi* seed, which can also be sown with rain after the 15th June.

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- (3) They have to overcome some difficulty in securing American cotton seed from the distantly located seed distributing centres, whereas *deshi* cotton seed is readily available everywhere.
- (4) American cotton requires more water and punctual waterings, whereas *deshi* cotton can do with less water and stand reasonable delays without injury.
- (5) American cotton cannot stand accumulations of rain water for the same length of time as the *deshi* cotton, and has to be sown in higher fields.
- (6) American cotton fields cannot be cleared in time for rabi crops, whereas peas and barley can be sown in fields under *deshi* cotton.
- (7) No other crops can be sown simultaneously in American cotton fields, as is done in those under *deshi* cotton.
- (8) The bolls of American cotton facing in all directions are easily damaged by rain, whereas *deshi* cotton bolls hang downwards and are not so easily damaged.
- (9) The cultivators do not succeed in producing the same quantity of cotton per acre from the American as from the *deshi* seed. The cost of production of American cotton is higher per acre by Rs. 3 and the rate for its sale being only Re. 1 per maund higher, there can only be a profit of Rs. 3 per acre by its preference. But this is not a sufficient figure to induce the cultivators to ignore the disadvantages enumerated above.
- (2) If the rate of purchase of American cotton is increased from Re. 1 to Rs. 3 per maund higher than that for *deshi* cotton, its cultivation is bound to increase in cotton growing districts.

3088. (74) Effect of canal regulations.—The canal regulations do not create any difficulties in regard to the cultivation of American cotton. Water is required for its *paleo* in the beginning of May when supplies in the rivers increase by the melting of snows in the hills during the hot weather, and there is no shortage of water in those canals on which the production of cotton is preferred to that of sugarcane and rice.

3089. (72) Adequacy of supplies to increase of area under cotton.—It is not the water supply in the canals which is sufficient guarantee for increasing the area under cotton. There are several other factors, too numerous to mention, which play an important part in the decision of cultivators to give preference to some crops over others.

3090. Condition affecting increase in area under cotton.—Cotton best thrives where the average monsoon rainfall is comparatively less. The nature of soil and the condition of its flooding during the rainy season are the main determining factors for adoption of cotton cultivation. The distribution of wealth among the cultivators of the various districts commanded by canals has also a direct bearing on the adoption of crops requiring expenditure of capital (e.g., sugarcane), assurance of markets (e.g., indigo, poppy) and safety from weather (e.g., cotton).

(2) To illustrate the above, I shall quote the average figures for five years ending 1916 for the various canals of which I have had experience, viz. The Upper Ganges canal, The Lower Ganges canal, The Agra canal, and The Eastern Jumna canal.

(3) The following average areas were irrigated, on these four canals, during the above mentioned period under the three principal *kharif* crops, viz. : sugarcane, rice, and cotton, and the three principal *rabi* crops, viz., wheat, barley and gram.

CROPS.	QUINQUENNIAL AVERAGE ACREAGE FROM 1911-12 TO 1915-16,			
	Upper Ganges Canal.	Lower Ganges Canal.	Agra Canal.	Eastern Jumna Canal.
<i>Kharif.</i>				
Sugarcane	172,000	33,000	12,000	71,000
Rice	28,000	52,000		41,000
Cotton	147,000	153,000	92,000	12,000
Other <i>kharif</i> crops	173,000	139,000	29,000	37,000
TOTAL KHARIF	520,000	377,000	133,000	161,000
<i>Rabi.</i>				
Wheat	296,000	238,000	50,000	102,000
Barley	43,000	53,000	27,000	2,000
Gram	8,000	12,000	25,000	4,000
Other <i>Rabi</i> crops	249,000	302,000	37,000	41,000
TOTAL RABI	596,000	605,000	139,000	149,000
TOTAL ANNUAL AREA	1,116,000	982,000	272,000	310,000
Normal annual rainfall in inches	28.67	30.85	25.5	30.40

(4) A glance at this statement will show that—

- The total annual areas of the Agra and the Eastern Jumna canals are very nearly the same.
- The *kharif* and *rabi* areas of the Agra and the Eastern Jumna canals are nearly equal.
- The total annual area of the Upper Ganges canal exceeds that of the Lower Ganges canal by nearly a lakh of acres, but the *rabi* areas in both cases are almost equal, and the *kharif* area of the former exceeds that of the latter by nearly a lakh of acres.
- There is a great difference in the areas under the six crops, sown on each of the above two sets of canals irrigating practically equal areas.

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For example—

- (a) The Upper Ganges does 172,000 acres of sugarcane, whereas the Lower Ganges does only 33,000. The Eastern Jumna canal irrigates 71,000 acres of sugarcane, while the Agra canal does only 12,000.
- (b) More rice is irrigated on the Lower Ganges compared to the Upper Ganges Canal. Rice is not irrigated at all on the Agra Canal, whereas 41,000 acres are irrigated on the Eastern Jumna Canal.
- (c) Cotton area is equal on the Upper and the Lower Ganges canals but Eastern Jumna canal does only 12,000 acres of cotton, against 92,000 acres on the Agra canal.
- (d) Wheat, barley and gram are about equal on the Upper and the Lower Ganges canals, but their differences on the Agra and Eastern Jumna canals are noteworthy. The area under wheat on the Eastern Jumna canal is double that of the Agra canal, but the area under barley and gram on the former is very small compared to the latter.
- (5) Although the average areas of the Upper and Lower Ganges canals do not show great difference in the above statement, it does not follow that conditions in the various districts or divisions of the two canals are identical. If Meerut division is taken to represent a part of the Upper Ganges canal and Etawah that of the Lower Ganges Canal, a comparison of sugarcane, rice and cotton areas shows the following differences :—

Areas irrigated in kharif 1913-14 and 1914-15.

	Meerut division, Upper Ganges Canal,		Etawah division, Lower Ganges Canal,	
	(1913-15).	(1914-15).	(1913-14).	(1914-15).
	Acre.	Acre.	Acre.	Acre.
Sugarcane	52,240	47,213	5,359	4,877
Rice	2,275	3,452	13,944	16,462
Cotton	8,250	12,115	55,954	48,430
TOTAL	81,083	80,958	126,233	122,320

Meerut division in kharif is essentially a sugar division, whereas Etawah division is a cotton division.

(6) From the above facts and figures it is obvious that it will not be correct to expect a substantial increase in cotton area on canals where the conditions of soil, rainfall and agriculturist are unfavourable to the production of that crop.

3091. (69) Wells and tube-wells.—The canal water is fully utilized to the best advantage during the *rabi* season, but if it is as economically used during the *kharif* also, a considerable increase in cotton area may be effected in divisions suitable for its cultivation. The existing number of wells in areas commanded by canals is low, as the canal water-rates are cheaper and the cultivators do not consider it necessary to invest in *putka* wells. *Kachcha* wells do not last long near canals. If suitable measures are taken to increase the number of wells where canal water does not reach and where the soil is favourable for cotton production, a further increase in the area under this crop can be obtained. Tube wells have not yet been seen working in the canal-irrigated tracts. A *putka* well ordinarily costs Rs. 500 and a *kachcha* well Rs. 25. About eight acres can be irrigated from the former and three from the latter which has to be renewed after three or four years.

3092. Cotton versus wheat.—Wheat is sown during *rabi*, by way of necessity. It is not possible to sow wheat in cotton fields, as the latter crop matures in September and by the time the picking is complete in October it becomes too late to plough and prepare fields for wheat sowings. A field in which wheat is sown has to be ploughed up again and again at least six times, and the number of such ploughings usually rises to ten or more. The deeper a wheat field is ploughed and the greater the number of its ploughings, repeated after prolonged intervals, the better the results. The ploughing of fallow land is commenced with the first fall of monsoon rain in July and continued during breaks. It is vigorously pursued when the monsoon disappears in September. The seed is sown from 15th October to 15th November. In wet years the sowings are delayed for a fortnight or so. Wheat can be sown in *kharif* fields, if the crop be indigo or maize. No regular weeding is necessary in wheat fields, but jungle has to be rooted out gradually, as necessity arises, specially when the field has not been previously well prepared by continued ploughing.

(2) The yield and profit of wheat and cotton per acre may be roughly compared. The cost of cultivation is nearly the same on all the canals, but the average outturn differs considerably, e.g., taking pre-war rates.

	Wheat. Outturn of average full crop, per acre in maunds.	Cotton. Value per acre of average full crop.
	Rs.	Rs.
Upper Ganges canal	16	43
Lower Ganges canal	16	44
Agra canal	15	54
Eastern Jumna canal	18	34
Average 16 maunds = Rs. 48	—	44

These average figures may be accepted to give the yields per acre in the two cases.

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Continued.

(3) The average cost of production per acre of wheat and cotton is as follows :—

Wheat.		Cotton.	
	Rs.		Rs. a. p.
(1) Seed at Rs. 30 seers per acre	4	(1) Seed 3 aers at Rs. 8 srs. per rupee	0 8 0
(2) Land rent per <i>fasl</i> at Rs. 14 per acre per annum	7	(2) Land rent per <i>fasl</i>	7 0 0
(3) Water rates at Rs. 4	4	(3) Water rates at Rs. 2	2 0 0
(4) Ploughing field 8 times at Rs. 2 each time	16	(4) Ploughing field twice at Rs. 2 each time	4 0 0
(5) Weeding	nil.	(5) Weeding 3 or 4 times at Rs. 2 each time	8 0 0
TOTAL	31	TOTAL	22 0 0

(4) A wheat field produces about Rs. 48 worth of wheat, two maunds, or Rs. 12 worth of rapeseed and twenty maunds or Rs. 10 worth of chaff for cattle, or a total yield of Rs. 70 per acre, and brings a profit of Rs. (70—31) or Rs. 39 to the cultivator. A cotton field, if it escapes the ravages of wet weather brings a profit of Rs. (44—22) or Rs. 22 per acre. This profit rises considerably on the Agra Canal and falls on the Eastern Jumna Canal. This accounts for the low cultivation of this crop on the latter and its universal adoption on the former.

(5) The cultivators prefer wheat to cotton as an irrigated crop, for the following reasons :—

- (1) Wheat cannot be sown in cotton fields immediately during the following *rabi*, but cotton can be sown in wheat fields during the succeeding *kharif*.
- (2) In weeding the cotton crop, the cultivator has to incur cash expenditure by employing a large number of labourers to finish it in a short time. Wheat does not require any weeding. The necessary jungle clearance can be done gradually by the members of his family circle.
- (3) The outturn of wheat is practically assured in cold weather, but that of cotton remains at the mercy of the monsoon rainfall.
- (4) Wheat gives fodder for cattle which every cultivator has to maintain, whereas cotton does not produce any fodder.
- (5) Wheat can be stored in granaries, till markets are favourable, while cotton is difficult to store in village huts.

3093. (68) Fluctuations in river supplies and their effects.—The supply in the rivers increases gradually in spring and decreases gradually in autumn. The cultivator decides upon a rotation of crops according to his means, the nature of his holdings, the fertility of the soil and its suitability for a particular crop, the prices ruling in the market, the facilities for irrigation, the conditions of weather, the existing means of communication to the most favourable markets, and similar other considerations. He tries to get double crops from his fields, if possible, without considerably reducing their fertility. He leaves them uncultivated in some *fasls*, to give them rest and to produce a rich crop in the succeeding *fasl*. His decisions are not, however, based on any well-considered programme of rotation and are mostly arbitrary. As a rule, he is guided by the dates when the operations for each crop begin and end. For example :—

Kharif.

- (a) Sugarcane is sown from January to end of March, and its pressing is completed from December to March.
- (b) Indigo is sown from 15th March to 15th May and removed to factories during August.
- (c) Cotton is sown from 15th May to 15th June, and the picking is completed in October.
- (d) Maize is sown in June, and harvested after sixty days, in August.
- (e) Millets are sown in July and August, and do not require any irrigation from canals or wells.
- (f) Ordinary rice is sown in April and May and harvested in August.
- (g) Transplanted or '*ropa*' rice is sown in June with canal water and is transplanted from 15th July to end of August. It is harvested from 15th November to 15th December.

Rabi.

- (h) Wheat and barley are sown from the 15th October to the end of November, and harvested in March or April.
- (i) Peas are sown in December, and harvested in March.
- (j) Gram is sown on sandy elevations (*bhoor*) from 15th October to 15th November and harvested in March.
- (k) Poppy is sown in November, and is matured in March.

(2) More manure is required for sugarcane, wheat, cotton and maize, compared to gram and peas. No manure is necessary for indigo, as its leaves are converted into excellent manure with lapse of time. Double crops are sown where the above dates admit of fresh sowings and the facilities for manuring are available. No crop is sown in the same field immediately after sugarcane. It remains fallow for one *fasl*. In fields which are under wheat during *rabi* they can sow indigo, cotton, maize, jwar, rice, etc., during the following *kharif*, but weak fields are given rest for a *fasl*. The double-cropped area in some canal divisions rises to 75 per cent.

3094. (71) Cropping and causes affecting it.—A cultivator having a holding of 100 acres in Etawah division in the beginning of *kharif* usually leaves 25 acres uncultivated for sowing wheat, during the ensuing *rabi*. Of the remaining 75 acres the *kharif* area is sown as follows :—

Sugarcane	10
Cotton	15
Indigo	20
Maize	15
Millets	10
Fodder	5
	35 acres.

The 35 acres under indigo and maize are practically treated as double-cropped for the next *rabi*, and he sows ten acres out of the 35 with wheat, ten with mixed wheat and barley, and fifteen with peas, gram and barley. The total area under pure wheat thus amounts to 35 acres.

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3095. (70) Suitability of existing water rates.—I consider the existing water rate for cotton suitable from the cultivator's standpoint. The following water rates are at present in force for 'flow' irrigation on the above mentioned canals :—

	Rs. a. p.
Sugarcane and rice	6 10 8 per acre.
All <i>rabi</i> crops except gram and peas, etc.	4 0 0 „
Gram, peas, lucerne, linseed, and all <i>khari</i> crops except sugarcane, rice and poppy, etc.	2 0 0 „

Half rates are charged for 'lift' irrigation.

3096. (2) The lowest rate is Rs. 2 per acre and cotton is being charged at this rate. No more reduction is desirable. I have shown above, in paragraph 7, that 35,000 cubic feet of water are required per acre of cotton crop. The rate for canal water supplied in bulk is Rs. 1 per 5,000 cubic feet, and Rs. 7 should be due for an acre of cotton field at this rate. Considering that the cultivator has only to pay less than one-third, he has no just cause for complaint. The Canal Department is certainly losing much by assessing this low rate on the cotton crop.

Mr. RAJ NARAIN, B.A., called and examined.

3097. (Mr. Ashton.) The water supply in my division is ordinarily more than sufficient for our full requirements in the month of April and up to middle of May. I am speaking of the Etawah division in which I am at present working. In the Meerut division, it is insufficient as there is sugarcane in that division in that season. If water in my division were given for American cotton, it would mean a curtailment of other crops. The cultivation of American cotton can be extended but it does not depend upon the water supply in this division. We can give water in the above months to any extra area if the cultivators want it. If the channels are opened in alternate weeks, then the area under irrigation would be just the same as if they were kept open continuously in the above months. The requirements remaining the same, the area of cultivation would not be extended. The cultivators decide the area which they are going to irrigate beforehand. We give them water but the same field is irrigated over and over again. Crops requiring many waterings are sown instead of the area under irrigation being increased.

3098. In fixing the discharge of outlets no consideration is paid to the question of duty. When the head discharge of a channel is fixed, a certain factor is adopted called the factor of discharge. It is different from duty. A different factor is taken for *khari* and *rabi*. The head discharge of a distributary is designed on the basis of whichever is the greater of these two. The factor usually employed in this division for *rabi* is 120 acres per cuasee at the distributary head. The six-inch outlets usually irrigate one hundred acres each. One foot head of water through a six-inch outlet will give about one cuasee of discharge sufficient to irrigate about one hundred acres. A calculation of 120 at the head of 100 at the tail allows for loss by evaporation and percolation.

3099. (Mr. Henderson.) There is not much American cotton in this division. There is a little near Cawnpore and some in the Harehandpur Court of Wards Estate. The amount is very small. There is not much to choose between *deshi* and American cotton. I have not seen any failures. The year has been very bad for cotton, as bad as I have ever known. American cotton should do better in an ordinary year. The rainfall has been heavier than it has been for twenty years. A premium of Rs. 3 per maund for American cotton would tempt the cultivators to grow American cotton. The objection, however, to this would be that it would simply mean that the cultivators would not increase the area under cotton but would replace *deshi* cotton by American. American cotton is a new crop and there is no market for it. Ordinary purchasers pay the same rate for American as they do for *deshi* as they do not know the American cotton. The objections to American cotton might vanish if the cultivators got a premium of Rs. 3 for it. There are no irrigation difficulties in regard to the sowing of American cotton in May. *Deshi* cotton is sown at the same time. Pulses will not grow with American cotton. The Agricultural Department does not recommend their being sown with American cotton. The cultivators might be able to sow *arhar*. There are difficulties in getting the seed of American cotton at present. I heard of one cultivator in a village twenty miles from Cawnpore who sowed American cotton but he could not dispose of it at a proper price, as the village purchasers seemed to think that if they bought it they would be prosecuted by Government and in consequence, he had to sell it at a lower rate in Cawnpore. The cultivator has to get his seed from Cawnpore. A premium of one rupee per maund for American cotton is insufficient. A greater inducement to the cultivator is required. If the factories wanted American cotton it should be forthcoming. We should raise no irrigation difficulties.

3100. (Mr. Roberts.) The water supply was concentrated in the Reona and Akbarpore distributaries last year. I do not think that this policy can be extended to any great extent. If American seed were distributed and if the cultivation of cotton were concentrated on forty per cent. of the channels, difficulties would arise and, as a result, the cultivators would have their cotton at the expense of other crops.

3101. (President.) The extension of American cotton can only be at the expense of other crops principally *deshi* cotton. *Deshi* cotton is the crop which will be most affected by an attempt to introduce American cotton. The cultivator will have to overcome certain difficulties in marketing and the like.

Mr. H. J. HOPE, Executive Engineer, Northern Division, Ganges Canal, United Provinces.

EXAMINED AT CAWNPORE, NOVEMBER 1ST, 1918.

Written statement.

VI.—IRRIGATION.

3102. (65) Experience.—I have sixteen years' service in the Irrigation Department of the United Provinces, and all but about three years have been spent on the Upper and Lower Ganges and the Agra Canals entailing canal irrigation assessment work.

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Mr. H. J. Hore.

[Continued.]

3103. (68) *Fluctuations in river supplies and their effects.*—All the canals mentioned in the preceding paragraph take off from snow fed rivers and consequently suffer from short supplies of water during the winter months. The shortage is generally most severely felt in February, when the *rabi* crops are requiring their final waterings. There is then generally only enough water available to enable us to run our distributaries on the Upper and Lower Ganges Canals one week in three, and on the Agra Canal one week in four. In March, the demand for water slackens as the *rabi* crops ripen. From the beginning of April, demand starts rising again for the irrigation of sugarcane, vegetables, and gardens. Towards the end of April, the arrival of muddy water marks the commencement of the melting of the snows in the Himalayas and the supplies gradually increase until, from the middle of May, there is generally enough water to enable us to run our distributaries on the Upper and Lower Ganges Canals two weeks in three, and on the Agra Canal one week in two. This season is not a critical period for our Canals, and experience shows that if we design our irrigating channels to carry enough water for the irrigation of the areas under either—

- (1) *Rabi* crops, or
- (2) *Rabi* plus sugarcane, or
- (3) Rice,

then they are easily able to cope with all demands for irrigation during April, May and June. With existing methods of irrigation however, there is no water to spare for an increase of irrigation from the Agra Canal during these months, but on the Upper and Lower Ganges Canals, I should say the irrigating channels and supplies of water available are capable of irrigating an area quite five per cent. more than is irrigated during these months at present.

3104. (66) *Watering of cotton.*—Preliminary irrigation for cotton begins about the middle of May, and requires a depth of about six inches of water. The seed is sown about a week later. Generally no further water is required, but, if there is no rain up to the 15th June, another watering of about four inches depth will be required, and if the monsoon holds off, subsequent waterings, each of about four inches in depth, would be required at intervals of about three weeks.

3105. *Experience of temporary outlets for irrigation of American cotton.*—In the Cawnpore division of the Lower Ganges Canal, I had experience of giving temporary outlets in my distributary channels for the irrigation of American cotton in the years 1913-1916. I found in practice that water is required hardly any earlier for American cotton than for ordinary cotton. American cotton was then being pushed by Mr. Burt of the Agricultural Department, and we co-operated by giving temporary outlets in our distributaries wherever he recommended. I found, however, that the temporary outlets were irrigating twice as much area of other crops as of American cotton, and after two years' experience, it was obvious that the cultivators were agreeing to sow American cotton, not from any keenness for the crop, but merely for the advantage of getting a temporary outlet for the irrigation of their crops in general. Moreover, the grant of temporary outlets is unsound and unsettling, so I represented that they should not be given in future. Mr. Burt, however, pressed for their continuance, and I agreed on the understanding that they were to be recognized merely as baits to the cultivators to apply to Mr. Burt for American cotton seed.

3106. (73) *Deshi versus American cotton.*—I have frequently asked cultivators whether they prefer American or ordinary cotton. They acknowledge they get a better price for the former, but they do not consider it gives as good a yield as ordinary cotton. But whatever the reasons may be, I am convinced that the cultivators do not favour American cotton. I consider much more collective discussion and definite and general scheme is desirable before any crop is allowed to be pressed on the cultivators; as, unless success is achieved, their natural prejudice against innovations is bound to be enhanced to the detriment of the introduction of some really good discovery later on.

3107. *Fluctuations in the area of cotton irrigated and their causes.*—I submit three statements showing the areas of different crops, and the total areas irrigated by the Upper and Lower Ganges and the Agra Canal for the last thirty years. This shows a marked increase in the areas of cotton irrigated from the canals though this is mostly due to the displacement of indigo, and partly to the reduction since 1903 of the rate charged for canal irrigation of cotton from Rs. 3 to Rs. 2 per acre. Without irrigation, cotton is sown as soon as the monsoon commences, i.e., about the beginning of July, and a disadvantage to it is that, after harvesting, there is no time left to sow a *rabi* crop in the same field. The cultivators gradually discovered that to sow their cotton a month earlier with the help of canal water gave them an increased yield, saved them from the uncertainties of sowing at the first burst of the monsoon, and enabled them to get in a *rabi* crop. A series of favourable seasons gave encouraging results and there is no doubt this contributed to the increase in the areas of cotton irrigation. But in the last few years the monsoons have continued well into September and the late rains have damaged the flowering plants of the early sown canal cotton whereas the late rain sown cotton, flowering later, has escaped. This must be giving a set-back to the practice of sowing cotton early.

(2) Owing to the uncertainties mentioned in the foregoing paragraph, there is no doubt that the cultivators prefer sowing a *rabi* crop to sowing cotton, especially in canal irrigated tracts where they are assured of a good harvest irrespective of rain. Moreover, wheat is a much more paying crop, and is generally looked upon as the rent paying crop. We would welcome an increase of cotton irrigation, as both our distributaries and water supply are capable of meeting an increase, but it would be very difficult to get round the cultivators' preference for *rabi* crops.

3108. (70) *Suitability of existing water rates.*—The rate we charge for cotton irrigation is our lowest rate, namely, Rs. 2 per acre regardless of the number of waterings taken. I consider that this rate is not felt by the cultivators and that no advantage would be gained by reducing it.

United Provinces.]

Mr. H. J. HOPE.

[Continued.]

ANNEXURE I.

Statement showing the areas of different crops irrigated by the Upper Ganges Canal.

(All areas are in acres.)

Year.	KHARIF.						RABI.						GRAND TOTAL.			
	Sugarcane.	Rice.	Maize.	Millet.	Indigo.	Cotton.	Other crops.	Total.	Wheat.	Barley.	Gram.	Peas.		Other food grains.	Other crops.	Total.
1881-82	90,880	41,099	..	..	129,560	27,071	10,352	208,082	321,868	..	..	..	143,410	8,061	473,338	772,301
1882-83	109,201	51,387	..	..	141,435	20,558	14,875	228,245	3,342,603	..	..	..	165,843	10,023	518,329	836,035
1883-84	85,494	97,125	..	..	133,903	43,568	23,999	300,685	397,041	..	..	..	214,460	14,400	675,901	1,011,990
1884-85	86,510	56,500	..	..	171,325	32,805	17,029	277,659	224,442	..	..	..	88,258	7,070	319,770	683,939
1885-86	98,481	39,161	..	..	110,294	22,526	21,843	103,824	270,161	..	..	..	159,377	19,793	449,331	741,636
1886-87	90,653	43,405	..	..	69,398	17,870	15,107	145,780	219,050	..	..	..	107,496	10,862	338,008	574,441
1887-88	106,006	40,452	..	..	80,336	21,052	13,446	155,486	228,051	..	..	..	103,293	9,065	340,412	601,904
1888-89	125,267	40,515	..	..	83,703	16,774	24,023	163,075	226,656	..	..	..	71,586	19,680	337,922	628,264
1889-90	98,116	40,024	..	..	114,435	18,699	16,615	195,773	330,414	..	..	..	136,710	16,561	523,083	807,574
1890-91	109,516	50,214	..	..	110,259	29,362	16,803	212,338	334,119	..	..	..	133,922	11,757	499,798	821,052
1891-92	139,306	63,006	..	..	83,769	38,130	18,522	203,427	328,293	..	..	..	147,918	13,920	490,131	832,864
1892-93	115,215	69,845	..	..	66,571	30,480	23,071	196,553	302,958	..	..	..	96,797	10,955	410,710	722,478
1893-94	119,131	42,000	..	..	102,000	16,402	14,768	175,230	272,258	..	..	..	80,108	10,018	362,384	650,757
1894-95	118,987	27,912	4,824	3,077	119,170	10,496	17,121	182,600	38,882	2,318	155	168	4,787	3,740	50,050	351,037
1895-96	111,351	28,036	8,168	2,674	101,591	11,866	20,981	173,336	339,854	16,708	8,056	14,242	78,137	17,013	474,010	739,297
1896-97	128,282	51,037	46,223	10,902	133,904	40,121	21,021	313,998	429,846	30,000	12,841	23,685	124,847	19,135	640,954	1,083,234
1897-98	136,016	43,824	24,011	7,241	110,384	22,695	20,972	255,127	384,314	24,816	13,434	19,637	88,412	12,260	542,879	914,022
1898-99	147,285	35,081	24,032	5,586	68,338	26,281	20,878	180,796	416,122	24,507	6,538	17,168	93,378	13,808	573,521	901,002
1899-1900	157,338	34,929	95,738	33,403	66,363	56,255	51,539	340,227	318,582	49,861	8,363	28,019	39,540	19,671	764,030	1,201,601
1900-01	127,839	38,605	21,997	14,357	106,303	49,210	30,067	290,530	287,564	9,614	1,696	11,502	121,680	22,082	665,421	1,056,803
1901-02	130,472	48,370	46,307	12,730	43,477	71,124	38,902	260,910	436,493	37,552	15,508	32,100	62,167	13,123	665,421	1,201,601
1902-03	155,257	35,591	10,628	8,716	23,554	66,530	37,451	172,470	383,322	16,856	7,838	24,112	95,526	16,481	544,135	871,802
1903-04	148,012	33,985	32,206	12,013	39,333	70,680	32,472	290,689	412,112	25,850	5,827	23,486	120,758	20,918	608,951	977,652
1904-05	156,703	32,713	26,929	6,481	15,821	99,289	34,069	214,902	274,662	13,009	1,451	23,577	107,300	24,947	818,531	918,531
1905-06	106,510	35,228	110,992	38,284	3,776	204,975	42,969	465,214	314,625	28,647	16,895	77,269	235,930	24,303	797,669	1,369,393
1906-07	120,980	29,505	25,356	15,163	7,275	187,301	47,307	292,427	303,880	19,161	4,267	40,542	131,380	16,865	516,095	934,502
1907-08	153,108	32,993	114,316	29,143	10,828	176,794	47,707	314,702	278,087	38,036	10,910	81,857	182,641	20,703	729,488	1,304,744
1908-09	140,139	28,158	21,558	21,558	8,811	158,000	48,277	219,708	268,335	31,687	5,749	52,322	161,504	11,868	596,933	1,031,774
1909-10	163,369	28,663	23,815	9,295	10,170	105,488	48,277	219,708	268,335	31,687	5,749	52,322	161,504	11,868	596,933	1,031,774
1910-11	164,576	24,903	45,940	15,025	7,547	126,890	48,277	219,708	268,335	31,687	5,749	52,322	161,504	11,868	596,933	1,031,774
1911-12	189,771	23,396	67,013	32,715	8,812	144,764	71,218	347,918	252,080	21,465	6,944	46,158	126,163	9,654	443,300	980,989
1912-13	191,192	27,703	34,229	15,793	8,001	138,701	50,210	274,640	306,912	53,301	11,604	98,213	185,959	23,411	652,967	1,179,497
1913-14	183,461	27,049	70,826	17,988	8,080	170,070	52,026	343,039	278,579	53,301	11,604	98,213	185,959	23,411	652,967	1,179,497
1914-15	150,547	29,313	52,817	28,020	8,053	190,709	82,109	391,021	323,676	62,562	10,270	47,853	161,639	20,057	603,821	1,147,389
1915-16	149,811	37,130	126,374	23,763	16,979	89,602	82,265	378,313	317,692	62,562	10,270	101,135	218,771	23,479	733,909	1,262,033

United Provinces.]

Mr. H. J. HORR.

[Continued.]

ANNEXURE II.

Statement showing the areas of different crops irrigated by the Lower Ganges Canal.

(All areas are in acres.)

Year.	KHARIF.					RABI.					GRAND TOTAL.					
	Sugarcane.	Rice.	Maize.	Millet.	Indigo.	Cotton.	Other crops.	TOTAL.	Wheat.	Barley.		Gram.	Peas.	Other food grains.	Other crops.	TOTAL.
1881-82	20,084	10,989	..	..	163,392	1,168	8,916	184,465	210,109	..	..	..	193,536	23,011	420,656	631,205
1882-83	24,291	11,095	..	..	150,376	508	8,680	170,859	193,358	..	..	..	103,019	24,490	410,867	606,017
1883-84	16,806	32,901	..	..	137,140	3,366	9,975	183,382	232,037	..	..	..	194,357	27,158	453,572	635,820
1884-85	10,500	7,235	..	..	174,871	1,326	4,062	188,394	174,480	..	..	..	140,054	13,336	335,879	534,833
1885-86	16,839	8,562	..	..	151,900	1,132	16,212	177,822	124,075	..	..	..	127,370	16,187	207,641	462,302
1886-87	18,872	7,033	..	..	160,639	1,756	13,103	185,468	135,468	..	..	..	102,016	13,196	251,380	350,003
1887-88	22,170	8,981	..	..	100,667	2,232	13,635	125,506	149,405	..	..	..	160,324	13,528	323,257	470,942
1888-89	21,215	12,018	..	..	11,664	1,587	15,148	140,717	163,241	..	..	..	178,325	15,242	357,090	519,022
1889-90	17,053	26,814	..	..	73,490	1,588	16,887	119,779	167,374	..	..	..	178,015	17,072	302,401	499,893
1890-01	21,307	40,338	..	..	93,853	3,386	14,640	152,417	225,434	..	..	..	228,461	14,953	468,848	642,632
1891-02	27,380	50,384	..	..	82,620	6,840	15,139	155,283	247,744	..	..	..	214,858	15,698	478,300	660,963
1892-93	29,478	31,783	..	..	62,142	3,209	14,121	131,255	174,827	..	..	..	234,596	13,853	423,276	584,009
1893-04	19,180	35,937	..	..	135,603	1,949	13,286	186,811	119,573	..	..	..	157,332	12,757	319,802	525,853
1894-95	19,509	16,992	3,025	2,199	150,451	2,067	27,916	202,050	938	198	52	106	1,282	7,408	8,984	231,143
1895-96	31,907	39,382	10,945	4,997	99,715	1,700	17,953	174,692	190,500	46,215	18,075	13,850	135,658	29,474	400,381	666,880
1896-97	24,661	41,021	30,592	88,390	153,610	24,104	19,289	358,256	297,571	61,434	7,704	14,556	233,711	44,369	659,745	1,042,662
1897-98	21,820	34,734	62,392	8,121	133,540	3,045	32,312	274,150	251,040	64,903	8,754	12,943	202,002	29,470	570,612	860,591
1898-99	26,617	32,038	21,153	4,131	62,461	3,018	27,176	150,607	259,452	47,754	10,427	15,131	161,080	32,467	526,014	704,138
1899-1900	31,597	44,732	21,735	34,796	59,998	5,912	33,097	202,300	282,245	44,237	9,754	14,598	137,361	47,284	535,479	769,376
1900-01	32,590	29,578	39,096	9,660	82,003	5,313	18,300	184,856	226,094	30,508	5,248	14,430	117,238	38,900	432,418	640,870
1901-02	32,503	42,762	35,368	23,326	31,584	22,936	23,537	179,533	290,509	11,272	12,253	21,241	166,475	42,173	574,225	786,161
1902-03	35,417	32,043	37,315	14,048	17,438	44,123	20,300	105,467	334,154	33,576	11,370	14,676	103,282	40,810	648,177	849,001
1903-04	36,454	13,834	38,533	28,161	20,403	60,793	25,064	198,808	369,273	33,721	11,990	27,982	182,840	55,579	681,397	906,659
1904-05	32,594	30,012	17,258	10,672	13,124	88,380	23,399	182,845	229,076	25,588	2,790	26,683	234,842	42,929	705,265	1,151,644
1905-06	28,774	37,947	17,677	97,575	9,213	102,171	33,722	147,605	290,590	12,512	26,018	30,966	234,842	53,747	705,265	1,151,644
1906-07	35,057	46,172	59,035	27,882	5,273	118,043	27,987	284,392	269,005	38,753	10,542	42,802	197,445	15,430	603,977	924,026
1907-08	41,404	60,936	71,870	97,637	11,477	115,529	27,830	415,279	262,247	52,341	17,219	45,226	232,286	57,488	707,061	1,163,747
1908-09	23,731	48,305	48,005	32,231	4,483	114,443	20,763	269,190	234,513	40,117	13,145	15,226	220,869	34,902	594,802	887,723
1909-10	22,634	55,177	35,402	15,924	5,167	73,015	16,712	201,412	231,433	49,436	10,297	44,782	231,435	20,932	594,715	818,701
1910-11	23,337	24,800	46,031	18,532	4,219	79,095	12,229	187,992	233,138	49,944	5,726	38,980	182,257	29,633	539,761	731,033
1911-12	36,926	37,420	51,278	74,912	4,657	139,509	20,010	327,914	172,098	31,522	4,207	50,480	150,530	17,395	426,532	701,372
1912-13	44,855	33,347	32,709	80,548	3,638	149,350	17,782	260,233	230,378	34,732	8,358	70,767	197,264	13,852	555,551	860,639
1913-14	25,775	53,557	53,001	80,548	3,638	149,350	23,769	431,100	271,714	31,923	18,313	84,098	282,489	34,500	743,037	1,199,918
1914-15	21,453	65,035	76,059	47,929	1,391	207,778	30,007	429,102	263,910	70,243	17,039	66,841	218,508	20,481	657,028	1,107,583
1915-16	34,041	70,732	60,880	20,959	12,406	64,337	31,071	272,463	250,008	77,064	13,709	68,005	206,334	25,676	947,842	1,199,918

United Provinces.]

Mr. H. J. HOPE.

[Continued.]

ANNEXURE III.
Statement showing the areas of different crops irrigated by the Agra Canal.

(All areas are in acres.)

Year.	KHARIF.					RABI.						GRAND TOTAL.				
	Sugarcane.	Rice.	Maize.	Millet.	Indigo.	Cotton	Other crops.	Total.	Wheat.	Barley.	Gram.		Peas.	Other food grains	Other crops.	TOTAL.
1881-82	2,148	2,168	..	..	22,082	27,065	1,662	51,177	28,206	..	..	..	66,375	1,007	96,278	152,603
1882-83	5,472	2,525	..	..	19,387	21,827	2,012	45,751	27,392	..	..	..	75,217	2,025	104,064	155,887
1883-84	2,500	16,478	..	..	18,571	32,250	3,240	70,542	29,360	..	..	..	137,046	5,852	172,258	245,300
1884-85	1,010	4,692	..	..	38,496	26,316	991	70,418	29,696	..	..	..	34,690	1,108	56,404	128,002
1885-86	2,653	1,948	..	..	31,145	27,725	1,398	62,216	30,005	..	..	..	80,290	1,557	111,852	176,721
1886-87	2,346	1,973	..	..	20,582	18,174	1,559	48,288	19,717	..	..	..	50,115	1,600	71,402	122,096
1887-88	3,314	2,410	..	..	28,333	22,008	2,202	55,133	14,519	..	..	..	49,721	1,820	66,090	124,557
1888-89	4,304	1,350	..	..	23,543	15,063	1,812	43,768	19,626	..	..	..	55,379	1,357	76,362	124,434
1889-90	1,808	1,973	..	..	28,022	30,393	1,294	61,681	33,585	..	..	..	79,914	1,263	114,762	178,254
1890-91	1,731	2,779	..	..	10,087	31,203	4,167	48,236	26,425	..	..	..	71,018	4,108	102,151	152,118
1891-92	2,864	6,526	..	..	6,028	41,473	3,394	57,121	33,705	..	..	..	68,062	2,839	104,696	164,981
1892-93	3,365	2,109	..	..	8,081	25,787	2,834	38,814	31,880	..	..	..	31,845	1,150	64,875	107,054
1893-94	4,538	1,939	..	..	22,491	40,010	2,403	67,472	30,035	..	..	..	52,290	1,876	93,210	165,220
1894-95	5,147	..	80	1,725	33,067	35,171	2,439	72,501	25,573	2,652	16,236	213	13,518	1,323	61,515	139,166
1895-96	8,875	3	53	1,757	16,002	27,850	2,032	49,197	50,100	4,381	34,235	702	56,415	1,988	126,430	184,502
1896-97	6,152	6	225	18,095	31,331	52,052	4,003	105,822	80,535	10,770	34,813	661	60,415	3,830	109,030	308,004
1897-98	4,160	..	847	5,704	30,235	52,838	3,685	93,438	52,971	10,231	17,571	702	34,556	1,823	117,857	215,355
1898-99	9,213	..	626	4,171	10,792	38,635	5,415	59,653	59,036	14,729	22,046	1,265	40,315	1,909	141,100	269,966
1899-1900	8,232	..	869	20,096	7,876	60,329	6,794	95,971	67,040	30,065	7,471	3,272	48,722	3,624	160,224	264,427
1900-01	5,694	..	1,879	7,939	12,440	86,269	3,199	111,747	52,822	4,764	3,094	1,624	6,803	2,729	72,736	190,177
1901-02	12,559	..	1,567	6,672	2,543	28,410	5,034	98,232	89,019	19,857	12,628	1,824	24,142	2,466	149,936	260,727
1902-03	8,107	..	775	3,065	1,658	88,635	4,617	98,754	81,013	10,389	16,403	791	18,593	2,581	129,860	236,721
1903-04	11,520	..	1,106	5,217	4,872	86,838	8,163	106,199	88,008	12,956	10,246	1,655	26,958	2,366	142,189	239,908
1904-05	10,456	..	870	1,839	2,728	103,491	7,150	116,078	36,987	7,260	5,462	1,495	5,347	2,212	58,763	185,297
1905-06	1,967	..	1,241	8,925	248	111,905	12,301	134,859	66,176	38,012	40,480	10,474	47,798	3,833	200,773	343,599
1906-07	5,092	3	2,391	2,785	1,064	125,963	12,644	144,750	52,199	15,533	12,344	5,347	17,071	2,140	104,634	251,476
1907-08	16,161	9	889	5,134	889	134,942	9,243	152,453	52,639	61,992	23,498	12,218	31,393	2,807	173,947	342,554
1908-09	17,612	8	461	1,812	227	62,705	23,810	89,023	36,787	26,861	17,070	4,727	18,001	2,061	106,110	212,745
1909-10	11,593	10	534	1,654	840	80,132	6,543	89,713	52,555	24,534	21,559	6,078	23,460	3,293	132,316	233,622
1910-11	10,827	8	545	2,394	443	75,123	6,939	83,452	38,905	7,876	8,431	3,360	11,361	2,182	72,175	168,454
1911-12	12,470	13	336	8,806	606	77,230	28,430	125,421	40,610	9,199	20,748	3,767	14,940	2,307	91,567	229,458
1912-13	20,892	20	180	2,650	918	73,119	15,838	92,134	57,465	13,970	25,508	4,418	13,945	2,423	122,629	235,565
1913-14	10,557	27	187	6,030	715	112,588	19,073	138,620	41,499	36,383	22,487	4,791	25,483	17,659	148,302	297,479
1914-15	3,684	35	1,383	3,825	459	119,985	23,904	149,591	48,781	28,229	28,128	2,233	25,779	5,792	138,942	292,217
1915-16	13,034	70	3,201	10,705	3,234	69,414	15,598	102,222	62,414	48,632	26,534	5,773	42,406	6,391	191,150	306,406

United Provinces.]

Mr. H. J. HOPE.

[Continued.]

ANNEXURE IV.

Statement showing American cotton in the Cawnpore Division under the Lower Ganges Canal.

Year.	Area sown.	Area irrigated.
1912	617	491 acres.
1913	455	359 "
1914	531	313 "
1915		201 "
1916		99 "
1917		104 "

Mr. H. J. HOPE called and examined.

3109. (Mr. Ashton.) Our irrigation channels in the United Provinces are nominally designed so as to allow one week's running and one week's closure. The distributaries of the Upper and Lower Ganges canals can, in an average year, run two weeks out of three in May, when the supply is in excess of that for which they were designed. In April, the cultivators are busy harvesting and the demand for water is therefore slack in the beginning of the month: towards the end of the month, the demand is fairly keen. The question whether the supply would be equal to a strong demand during that month has never really been tested as the demand is slack at that time.

3110. For the cultivation of American cotton last year, water was concentrated on four out of the twelve channels in the Cawnpore Division of the Lower Ganges canal. It was settled with Mr. Burt in what weeks the water was to be run and the channels ran about four weeks continuously. Later on the monsoon burst early. Concentration this year was done after I had left the division. The other channels which were deprived of water were not compensated afterwards. There was no necessity to do so as the monsoon burst early. Cawnpore American cotton has been going now for the last six years. There has been no response to the efforts which have been made to extend its cultivation and the areas under it are gradually dwindling. If American cotton became popular and was spread over large areas, there would, by concentration, be enough water for giving special extra supplies at the sowing time. I think the present water supply is quite enough for a greater area than at present under *khari* irrigation, and is capable of doing at least five per cent. more irrigation than is done at present. There is water to spare. As to whether there would be any hardship to the cultivators on other channels, or whether their crops would suffer at that time, my answer is that it depends upon the extent which you concentrate.

3111. (Mr. Roberts.) I do not think there is any irrigation difficulty in regard to American cotton in April, May and June. The cultivators concentrate their energies on the *rabi* crops because they are food crops. The statement in my evidence that American cotton requires water hardly any earlier than ordinary cotton is due to the fact that in 1916, I made arrangements to give a supply of water in April for American cotton but this was not taken advantage of as the cultivators were harvesting. Harvesting operations are an important factor as the cultivators concentrate on *rabi*. I don't think doubling the price of cotton would make the cultivators give up *rabi* for cotton. Mr. Burt gave every facility for American cotton but there has been no response and the area has been gradually dwindling; *rabi* is the big crop here.

3112. (Mr. Ashton.) One reason why the cultivators cannot sow American cotton early is the necessity for concentrating on the *rabi* harvest so as to get it completed before the monsoon.

3113. I think that the irrigated area could be increased or the water supply be more economically used by considering outlet *chaks* more scientifically, and by remodelling distributaries to run with bigger supplies and less frequently.

3114. I think the water rate on cotton is suitable and, in my opinion, it is hardly felt. You will see from the statement which I have put in that ever since the rate was reduced from Rs. 3 to Rs. 2 per acre in 1905, there has been a large increase in the area of cotton irrigation. This shows that even such low rates are of some consideration to the cultivators. The water rate on cotton is our lowest rate. It was so fixed with a view to encourage the growth of cotton. There was a change in all the rates in 1906. I do not consider that the water rate should be still further lowered.

3115. (Mr. Henderson.) The chief difficulties in regard to American cotton from the cultivators' point of view are that it needs more care than *deshi*. The cultivator is not able to sow a mixed crop. The cotton pickers are generally paid in kind (*i.e.*, in cotton) but when American cotton is grown, the labourers have to be paid in coin instead of in kind as there is no local market for American cotton as is the case with *deshi* cotton. American cotton remains for a longer time on the field and no *rabi* crop can be put in after it. It is true that it can be sown quite early in May, but even so, pickings go on till the end of November. Peas can be sown in December but it's late for them. The Punjab American gets a premium at the rate of Rs. 3 to Rs. 3-8 per maund above *deshi* and it would be quite reasonable to expect that American cotton produced at Cawnpore would fetch a premium of the same amount, but that is not the case. It gets a premium of only Rs. 1 to Rs. 1-8. The fact is that the monsoon is harmful to American cotton here, whereas there is no monsoon in the western Punjab. The yield is more uncertain than that of *deshi*. I think it is more affected by rain. I am certain the cultivators do not like American cotton. Even if the cultivators were paid a premium of Rs. 3 to Rs. 4 per maund, it is rather doubtful whether they should take to American. It may be argued that as the Punjab American has proved successful in the Punjab, there is no reason why it should not thrive in those parts of the United Provinces, which are contiguous to the Punjab, but I still think that there are too great fluctuations owing to the monsoon, which result in the yield being very uncertain. The eastern Punjab does not differ very much from the western United Provinces, but I do not think that American cotton has been successful on the Western Jumna Canal. It is in the western part of the Punjab that it has been successful, not on the Western Jumna Canal. Moreover the holdings in the Punjab are much bigger than in the United Provinces. Suppose you wanted to sow American cotton in May, water would be running for two weeks out of three weeks. That should be sufficient for your sowings. If a sufficiently large premium were paid, I do not think there would be any objection to the extension of the cultivation of American cotton at the expense

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The Hon'ble Mr. G. T. BARLOW.

of ordinary *deshi*. The only point is that the premium must be sufficiently high to cover all the uncertainties in the yield. I cannot say if a premium of Rs. 3 to Rs. 4 would be sufficient.

3116. (Mr. Roberts.) I have not discussed with *zamindars* the methods of collecting and marketing cotton or whether they find it difficult to bring it to the big centres. Special arrangements for collecting and marketing American cotton were made by Mr. Burt. Coolies are paid in kind for their labour in the cotton field, but in the case of American cotton they do not accept it as there is no local market for it and the villagers do not spin it.

3117. (Mr. Ashton.) In the United Provinces the sizes of our outlets are fixed upon past experience. Any area of from seventy to 110 acres of *rabi* would be given a six inch outlet. For areas under seventy acres, we would give a four inch outlet, but this method is very *kachcha*. The "duty" of outlets is not worked out as outlets discharge differently under different conditions. We do not regulate the discharges of our outlets, and there is no regular system of measuring discharges of outlets. We remodel our outlets on the basis of the areas actually irrigated compared with the proposed areas and reduce or increase the size of any outlet according to experience; but no alteration is made unless it entails a decided improvement as all changes are disturbing to the cultivators.

3118. (Mr. Henderson.)—Though the main distributaries run two weeks in three, the minor distributaries taking off from them only get about half that time, so that to obtain favourable conditions, American cotton should be sown on major distributaries, and not on minors. If this is done and two weeks in three is sufficient, as I think it is, there would be no need to concentrate our supplies of water on American cotton cultivation on a few selected distributaries.

The Hon'ble Mr. G. T. BARLOW, Chief Engineer, Irrigation Branch, United Provinces.

THIS WITNESS WAS NOT ORALLY EXAMINED.

Written statement.

VI.—IRRIGATION.

3119. (65) Experience.—I have worked for thirty years as an Irrigation Engineer in the United Provinces.

3120. (66) Watering of cotton.—Canal water is taken for cotton sowings from the latter part of May till the rains break in June. Water is only taken for sowing purposes, unless the rains break late, or there are long breaks in the rains.

3121. (67) Cotton *versus* wheat.—In most places the cultivators prefer wheat to cotton as an irrigated crop. Wheat must have irrigation; cotton can be sown roughly two weeks later without irrigation, if the commencement of the monsoon is not delayed.

3122. (68) Fluctuations in river supplies and their effects.—The supply in the rivers Ganges and Jumna increases gradually in the spring, and decreases gradually in the autumn. There is always plenty of water for cotton sowings, but the cold weather supply may limit the area under *rabi* crop. The small area irrigated under cotton has therefore nothing to do with the supply.

3123. (70) Saltability of existing water rates.—The existing water rates for cotton are extremely low, further reductions are not required.

3124. (72) Adequacy of supplies to increase in area under cotton.—There is ample water for a very much larger area. The area under cotton depends on prices, and on the local requirements for food grains and fodder crops. The limited area irrigated is due to the irrigated field only getting an advance of roughly two weeks over the field sown with rain water.

3125. (73) *Deshi versus* American cotton.—It is my experience that the cultivators prefer *deshi* to American cotton. American cotton requires more care, more labour, and the crop is seldom as profitable as a crop of *deshi* cotton followed by a *rabi* crop.

3126. (74) Effect of canal regulations.—To a certain extent the canal regulations create difficulties in regard to the irrigation of American cotton, because the United Provinces canals are generally designed for alternate week running, whereas constant running is more suitable for American cotton. This has, however, had no effect on the area sown. The small areas so far sown are entirely due to prejudice, real or imaginary, against the crop.

3127. American cotton in the United Provinces.—American cotton has not been a success in the United Provinces because the cultivators unquestionably prefer the *deshi* variety. The reason is, I think, clear. American cotton requires more care, more labour. The crop does not mature in time for a *rabi* crop to be sown and consequently may be considered a *do-fasli* crop. The outturn also is seldom as much as could be obtained by a crop of *deshi* cotton followed by a *rabi* crop. The supply in the Ganges and Jumna rivers, and consequently in the Ganges, Jumna and Agra canals increases gradually in the spring and decreases gradually in the autumn. As far as cotton is concerned, there is always plenty of water, and the canal irrigated area could be doubled without difficulty. The rates for the irrigation of cotton are exceedingly low, Rs. 2 for flow, and Re. 1 for lift irrigation.

(2) The area irrigated under cotton has greatly increased since the decline in indigo took place, but the recent boom in indigo has not affected the area. The reason why a much larger area of *deshi* cotton is not irrigated is not due to the water rate or to any deficiencies in the supply of water in the canals but merely because an irrigated crop only obtains the benefit roughly of a fortnight's advance over a crop sown by rain water. Water is generally merely taken for sowing the crop. It is only when the break of the rains is delayed or when there is a long break in the middle of the rains that further waterings from the canal are required.

(3) The canals in the United Provinces are in most cases designed for alternate week running and this appears to be a difficulty for the irrigation of American cotton as it appears that a first watering after sowing must be made after a certain number of days, and the system of alternate week running would cause delay in many cases.

(4) At the request of the Agricultural Department, we ran certain selected canals this year continuously for three weeks during the critical period. This could be done in the future as long as it was done on certain selected channels. It could not be done on every channel throughout the canals without remodelling all the channels. The expense of the remodelling would be enormous and the reduction in the *rabi* irrigation

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would also be great. It would be going back to conditions which existed 25 years ago, and returning to the hateful system of *latifs* which caused so much corruption and checked the full benefits of the canals. Such a retrograde step is impossible in order to secure a few scattered fields of American cotton. I am doubtful whether American cotton is really suitable for the United Provinces (my belief is that an improved *deshi* variety is the right thing to push) but if the agricultural experts say that American cotton is suitable, then I am sure the right way to push it is to concentrate at selected suitable places and systematically increase the area radiating out from the areas where the growth has been established, in properly understood and appreciated. If this is done, the Irrigation Branch will gladly assist in every possible way and, as far as I can see, no irrigation difficulties will arise.

II.—Central Provinces.

Mr. P. DAVIES, Executive Engineer, Central Provinces.

EXAMINED AT NAUGUR, NOVEMBER 14th, 1918.

Written Statement.

VI.—IRRIGATION.

3128. *Preamble.*—I have been asked to write a short note on the possibilities from an irrigation officer's point of view, of the development of long staple cotton on *bhata* soil in the tracts commanded by Government irrigation works in Chhattisgarh. I have spent eight years of my service in Chhattisgarh and have a fairly intimate knowledge of the tracts served by the local irrigation works, and particularly of the Mahanadi Canal.

3129. *Possibilities of cotton under irrigation in Chhattisgarh.*—The irrigation of cotton in Chhattisgarh is as yet in the experimental stage and until the present year no cultivation of cotton has been undertaken under the canals. During the current year, a number of demonstration experimental plots averaging about 25 acres have been started under the canal and tanks, but no irrigation has yet been done, so that for information as to number and depth of waterings required and the cost of cultivation we are dependent on the results obtained at the Government experimental farm at Chandkhuri.

(2) I propose, therefore, to confine my remarks to a brief consideration of the commandable areas available for cotton cultivation, the probable quantity of water likely to be required to serve these areas, the likelihood of its being obtainable and the water-rates that will be necessary to make it commercially possible.

3130. *Areas available for cotton cultivation.*—As regards the areas available, the tracts in question contain very large areas of *bhata* land but it has proved quite impossible in the short time, that has been available, to form even a rough estimate of the proportion of such that will come under actual command of the canals as considerable areas are high-lying and out of command. I have, however, discussed the available data with Mr. Blenkinsop, Commissioner of Chhattisgarh, who in his capacity as Settlement Officer, many years ago obtained considerable knowledge of the Raipur and Durg Districts and we have come to the conclusion that at a rough guess, 50,000 acres of *bhata* land will probably be available under the Mahanadi Canal and 70,000 acres under the Tandula Canal. If more or less accurate figures are required, they can be obtained and furnished with in four or five months.

3131. *Quantity of water required.*—To come to the question of the quantity of water required for the crop and the total volume of water likely to be required for the irrigation of the above areas on both canals. For the probable quantity of water required per acre, we are dependent on the figures given by the Agricultural Department and Mr. Clouston, Director of Agriculture, inform us that five or six waterings each of about two inches will be required on the fields from October to March. In support of this figure, I might state that we have recently made an accurate measurement of the actual quantity required per watering on a plot of one-tenth of an acre in area, and this worked out to about one-half of an inch in depth; this experiment was, however, made recently at the end of the monsoon, and the quantity used would certainly increase in the winter months as the ruball becomes drier, and it is also certain that the quantity used would be much greater in practical working. Mr. Clouston's figure of two inches per waterings would thus appear to be about correct and accepting also his estimate of say six waterings, the total depth required would be twelve inches on the fields or 41,000 cubic feet per acre. It would certainly not be safe to allow less than three times this figure for losses in transit and in the reservoir, so that the total quantity likely to be required would be about 176,000 cubic feet per acre or say 200,000 cubic feet per acre which is equivalent to a duty of five acres to the million cubic feet. On this basis, the Tandula Canal will require for its 70,000 acres, storage of 14,000 M.c. ft. and the Mahanadi storage of 10,000 M.c. ft. for its 50,000 acres. This estimate and all the calculations in this note are, of course, based on the assumption that the average duty of the rotated crops would be the same as that for cotton.

(2) To consider the case of the Mahanadi Canal first:—When the storage work now under construction is completed there is likely to be available sufficient water for at least 10,000 acres of cotton and rotated crops and the size of the catchment area is sufficiently great to allow of expansion up to, perhaps, 150,000 acres by the construction of additional storage schemes if suitable sites for such can be found.

(3) The Tandula Canal is unfortunately much less favourably situated. No water is likely to be available after the *khari* season except in years of exceptional rainfall, and it is a matter of doubt as to whether the existing supply will suffice for the rice crop. Investigations for additional storage are about to be made, but it is doubtful if this can be secured except at great cost by tapping the Mahanadi catchment which would involve not only the additional storage works, but a weir and a canal across difficult country for twenty miles, which between them would not be likely to cost less than Rs. 20 lakhs.

3132. *Water rate.*—To consider next the question of the water rate that would be necessary. On the Mahanadi, the cost of storage may be taken at the round figure of Rs. 400 per million cubic feet which at five acres to the M.c. ft. necessitates a capital expenditure of Rs. 80 per acre irrigated, and this with a return of five per cent will necessitate a minimum water-rate of Rs. 4 per acre plus say Re. 1 for maintenance charges of Rs. 5 in all. From the information I have been able to gather regarding the cost of cultivation at Chandkhuri Farm, I understand that the margin of profit is sufficiently great to admit of a higher water-rate than this.

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[Continued.]

(2) In the case of the Tandula Canal, 70,000 acres of cotton and rotated crops would necessitate additional storage of 14,000 M.e. ft. which would cost not less than Rs. 56 lakhs. Adding to this the cost of a weir on the Mahanadi and that of a canal to connect with the Tandula Canal at, say, Rs. 20 lakhs for both, the total outlay would be not less than 76 lakhs. The average water-rate necessary on 70,000 acres of cotton and rotated crops to give a return of five per cent *plus* Rs. 1 per acre for maintenance would be nearly Rs. 6-8-0 per acre.

(3) I should perhaps add that it may, in any case, be necessary to incur a portion of this outlay in order to make the Tandula Canal secure against failure in years of drought, and if this done the cost of providing water for the 70,000 acres under consideration will be proportionately cheapened.

(4) It may be asked why a portion of the supply earmarked for rice on the Tandula Canal could not be diverted to the irrigation of cotton, and it must be made clear that the construction of the Tandula Canal is being financed from the grant for Famine Insurance for the express purpose of protecting the staple crop which is rice.

MR. P. DAVIES called and examined.

3133. (Mr. Ashton).—I have had no experience on which I could base an estimate as to what quantity of water would be required, if the porous laterite soil of Chhattisgarh were utilised for the cultivation of cotton. I have had experience of the irrigation of sugarcane and groundnut. It is very difficult to say how much water we require for sugarcane, as we have hitherto irrigated only scattered plots, and scattered plots take a tremendous lot of water, much more than is required for large concentrated areas. But the figures that we have already got show that for sugarcane the duty is likely to be as much as one acre to one million cubic feet because sugarcane has to be irrigated all through the hot weather. For groundnut, we have no figures because it is impossible to separate it from other crops. Only one watering given in October or November and as other irrigation goes on at the same time, it is impossible to give separate figures.

3134. The total area that the Mahanadi Canal designed to command is in the neighbourhood of nine hundred thousand acres. It is designed to irrigate annually four hundred thousand acres. At a rough guess, there are fifty thousand acres of *bhata* land available under the Mahanadi Canal. The maximum storage that I believe could be made available would probably suffice for three times that figure. The water would be stored in reservoirs up in the catchment. Strictly speaking, the Mahanadi Canal, like the Tandula Canal, is a safeguard against failure or bad distribution of the monsoon and is therefore intended mainly for the rice crop but it is financed as a productive work. The supply that we are providing at present for the Mahanadi Canal will, I think, be sufficient even for the worst year on record for the rice, so that any additional water made available by additional storage would be available for cotton and *rabi* crops. Cotton has not yet been grown under irrigation under the Mahanadi Canal.

3135. I have not considered what area at present under irrigation would be fit for cotton in the whole of the Province; I have considered the question only in the case of Chhattisgarh.

3136. I think the probable minimum water-rates necessary to make the irrigation of cotton financially possible would be Rs. 5 and Rs. 6-8 per acre respectively on the Mahanadi and Tandula systems; a higher rate would be necessary if the cost of the additional storage proves to be greater than I anticipate. We have at present got no scheduled rate for cotton. For rice the cultivators pay varying rates. They have paid as much as Rs. 3-8 in certain cases but the average rate now is about Rs. 1-12 on works that have been in operation for some years. For sugarcane the rate is Rs. 10, and for groundnut it is Rs. 3. The rate for rice is lower than it is for groundnut. Groundnut has to be irrigated after the monsoon and we have to store water especially for that purpose. That is the reason for the higher rate. The rice crop has not to be irrigated after the monsoon.

3137. There is no doubt that the Mahanadi Canal could be expanded to irrigate very much larger areas than provided for in the project but the Tandula Canal is a different proposition altogether. The only way I can see of expanding the Tandula supply is from the Mahanadi catchment which, however, offers possibilities of providing storage sufficient for the requirements of cotton on both canals. We have roughly estimated that there are about one hundred and twenty thousand acres of available *bhata* land under both canals.

3138. As to whether, if it were found necessary to sow long staple cotton before the break of the rains, we could give the necessary water, I must explain that it would be an extremely costly business to store water for the hot weather. The rates would have to be put up fifty per cent or more. It would also mean reducing the area that could be irrigated. We could do it unquestionably for a small area.

3139. As to whether there are any other canals that command this laterite soil except the Mahanadi and the Tandula, in Chhattisgarh there are in existence a number of small tanks which command *bhata* land and there are likely to be large schemes undertaken in the Bilaspur district but it is quite impossible to give any idea of the area of such *bhata* land that these schemes will command. Water could probably be supplied to those tracts for cotton cultivation. There is likely to be a considerable extension of cotton under irrigation if it is proved to be a paying proposition. We do not irrigate the heavier soils except in the case of wheat and rice. We have not done any irrigation of cotton at all so far except purely experimentally.

3140. (Mr. Roberts).—It is very difficult to give reliable figures showing the areas that could be brought under irrigation for the cultivation of cotton in the Central Provinces. These figures could be collected if four or five months' notice were given. We would do our best to give this information. Of course figures could only be collected for the existing Government irrigation works and tanks and not for prospective works. It is next to impossible to give this information for prospective works; the country is so undulating that it is impossible without a survey to say what is commanded and what is not and the *bhata* land is nearly always on the top of the ridges.

Supplementary written statement submitted by Mr. P. Davies.

Note on the survey of bhata soils suitable for cotton under irrigation in the Central Provinces, dated April 17th, 1918.

3141. As promised, I now submit the results of the survey of the *bhata* soils suitable for cotton under existing irrigation works and works under survey in the Central Provinces. The surveys show that roughly

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38,000 acres of suitable *bhata* land can be commanded by existing works and probably 6,000 acres by new works at present under investigation, a total of 44,000 for the Province, all but 4,000 of which is in Chhattisgarh. In view of the necessity for rotating other crops with cotton it is probable that only half of the above or 22,000 acres would be actually available for cotton.

(2) We shall have water available for 14,000 acres of *bhata* land in the near future and that would mean 7,000 acres of cotton, but, for the remaining 30,000 acres special additional storage would have to be arranged for and as the bulk of the 30,000 acres is under the Tendula Canal, such additional storage would be expensive as stated in my note prepared for the Committee.

(3) I much regret that the results have proved so disappointing, but, although there are several hundred thousand acres of *bhata* land actually in the neighbourhood of the Mahanadi and Tendula Canals, almost the whole of it is high-lying and cannot be reached by flow. If, however, the cultivation of long staple cotton in Chhattisgarh proves to be sufficiently paying to make pumping a practical proposition, the areas available could be greatly increased.

The Hon'ble Mr. A. J. WADLEY, Chief Engineer, Irrigation Branch, Central Provinces.

THIS WITNESS WAS NOT ORALLY EXAMINED.

Written statement

VI.—IRRIGATION.

3142. *Preamble*.—As Mr. Davies is dealing with the irrigation of cotton on the red gravelly soil situated within the commanded areas of the Mahanadi and Tandula Canals in Chhattisgarh, I will confine my remarks to a few notes with regard to the prevalence of gravelly soils both red and yellow in some other parts of the Central Provinces.

3143. *Possibilities of cotton under irrigation in gravelly soils in the Central Provinces*.—These soils lie mainly on high land, ridges, and low hills. The proportion of such soils which lie in a position irrigable by flow is not large. Moreover the depth of soil is sometimes small, rock being met with twelve to eighteen below the surface. Nevertheless there is undoubtedly a proportion of it which is of good depth, and is irrigable. I know from personal inspection that there are small tracts of red gravelly soil in the Balaghat and Juppulpore Districts which are irrigable; in both cases schemes have been got out in the preliminary stage which include those tracts.

(2) The attached statement (Annexure I) has been compiled from Settlement Reports and District Gazetteers, and shows the areas of stony and gravelly soils in certain districts except the Raipur and Drug Districts which have been excluded, because a good deal of the *bhata* is situated within the area commanded by the Mahanadi and Tandula Canals.

(3) It will be observed that the total area of these soils amounts to 1,205,789 acres, but this does not represent all, because the classification of soils given in the Settlement Reports, from which the statement has been mainly compiled, does not embrace jungles or waste land.

(4) If we assume, and I think the assumption is a safe one, that five per cent of this total area will be irrigable, we get 60,289 acres of land suitable for long staple cotton and its rotational crop. Of this area one half would be cotton and the remaining half would be rotational crop. There would thus be 30,149 acres of cotton, say 30,000 acres.

(5) It would therefore appear worth while to make cotton growing experiments in other tracts beside the Raipur and Drug Districts. I am of opinion that a systematic survey for light gravelly soils would reveal appreciable areas situated in positions suitable for irrigation, and that it would be found possible to construct tanks to irrigate many of those areas. The special advantage of extending cotton into them lies in the fact that the people make very little use of such land under present circumstances.

(6) Although the description of the soils given in the statement is not at all promising, it is to be remembered that the five per cent, which it is suggested could be irrigated, would be the finer soil situated near the bases of the slopes. Cotton experiments made on the *bhata* soil at Chandkhuri Farm appear to have shown that long staple cotton does not need more than one watering a month, and that the quantity of manure required is not excessive.

3144. *Definitions of the various gravelly soils*.—In connection with the attached statement I wish to point out that the definitions of the various soils relate to them only when they are in waste lands and jungles. Now as the areas shown in the statement, under each kind of so-called poor soil, are cleared or cultivated areas not waste land or jungles, too much importance should not be attached to the definitions. The figures for the areas have been taken from the settlement "groups" given in the settlement reports. These groups are made up of cleared or cultivated land only, hence the soil in waste lands and jungles does not find place in them.

3145. *Possible area under cotton*.—We have therefore in these twelve districts 1·2 million acres of land which has been cleared and partly cultivated, but in which the cultivation, owing to the poorness of the soils (as hitherto regarded,) is of an inferior order consisting mainly of *kodon*, *kulki*, *tilli*, *jagri* and *jar*. Perhaps there are small areas of the better crops too, such as wheat and rice, but the bulk of the cultivation is inferior.

(2) Of this large area I have suggested, in my note, that a modest five per cent might reasonably be expected to be rendered suitable, by proper treatment, for cotton and its rotational crops, and might also reasonably be irrigable by flow irrigation. It is mainly the latter consideration which has led me to take so modest a figure as five per cent. However, I have based this figure to some extent on actual observation, for, during inspections made in September and October this year, I have seen at least 4,000 acres of these so-called inferior soils, which I know, will be irrigable by flow.

(3) I think therefore that the figure 60,000 acres, which I have given, is quite a safe one, but of course it would not be reached for many years to come, as the process of making tanks is a slow one, and the people are not yet accustomed to growing cotton, and although the proximity of Berar will no doubt help to bring cotton "on" there are many unknown factors at present.

3146. *Danger to cotton from frost*.—The Financial Commissioner mentioned to me that attempt to grow cotton in the plateau districts of Betul, Ohhindwara, Mandla and Seoni had not been successful owing to

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[Continued.]

the action of frost. Probably the sowings were made in June immediately after the burst of the monsoon. Mr. Clouston would know whether sowing have ever been tried in April in order to avoid frost. Special tanks, containing water ought during the previous monsoon, could be constructed to enable this to be done.

3147. *Water rate and profits to cultivators.*—I have the very highest opinion of the experiments which have been made at the Chandkhuri and Labandhi Farms, and of the results which are accruing therefrom, but unless the Irrigation Department receives a good water rate it will not be able to design special tanks for cotton and its rotations, and unless the cultivator receives a handsome profit, he will not willingly grow long staple cotton.

(2) A water rate of Rs. 5 (or Rs. 6 per acre in some cases) would, I think, meet the irrigation difficulty. With regard to the profit which the cultivator must get, the Agricultural Department would be the best judges. At page 691 of the Agricultural Journal for October 1917, profits of Rs. 58 and Rs. 42-9-6 per acre are mentioned as having been obtained from cotton grown in the Punjab.

3148. *Climatic drawbacks to introduction of long staple cotton.*—Since writing the above, I see from information supplied to the Superintending Engineer, Western Irrigation Circle, by Messrs. Clouston and Evans (*vide* Annexure II) that climate is likely to limit the introduction of long staple cotton more than I have stated in paragraph 3147. Frost and rain promise to be serious obstacles to its introduction in the north as well as in the plateau districts. The Agricultural Department will, no doubt, be able to give further particulars.

ANNEXURE I.

Statement showing the areas of gravelly soils (red or yellow) shown in the Settlement Reports or District Gazetteers of certain Districts in the Central Provinces.

<i>Saugor District.</i>	<i>Acres.</i>
<i>Bhatua</i> soil, poor land generally of reddish colour and covered with stones. Figures given in detail for settlement groups	44,936
<i>Damoh District.</i>	
<i>Bhatua</i> soil, stony land on hill sides and slopes, comprises one per cent of the total area <i>vide</i> Settlement Report, page 77	13,000
<i>Jubbulpore District.</i>	
<i>Bhatua</i> soil, red soil always shallow and stony, found on the slopes of hills and ravines. It can grow oil seeds and small millets at long intervals	84,397
<i>Barra</i> soil, hilly and covered with stones. It can grow <i>til</i> and <i>kodon</i> at long intervals. The value of the crop is said to be the same as that of <i>bhatua</i>	11,562
<i>Mandla District.</i>	
<i>Barra</i> soil, a red gravelly or moorum soil often extraordinarily stony or with rock underlying it within twelve to eight inch	207,906
<i>Seoni District.</i>	
<i>Barra</i> soil, a reddish coloured gravel thickly strewn with large stones but sometimes it is free of stones and at other full of large yellow flints. It occurs on high or hilly ground and is used for <i>kodon</i> , <i>kutki</i> , <i>tilli</i> and <i>jagni</i> (page 7, Settlement Report)	210,857
<i>Narsinghpur District.</i>	
<i>Bhatua</i> soil, poor soil occurring on or near hills of reddish colour and mixed with stones	26,898
<i>Hoshangabad District.</i>	
<i>Barra</i> soil, a poor soil reddish in colour and containing a large quantity of stones and pebbles	3,457
<i>Chhindwara District.</i>	
<i>Barra</i> soil, a very thin red soil much mixed with stones which occurs on high-lying ground. It is generally used for the production of <i>kodon</i> , <i>kutki</i> , <i>til</i> and <i>jagni</i>	100,453
<i>Bardi</i> , a very thin red soil much mixed with stones which occurs on high-lying ground. It is generally used for the production of <i>kodon</i> , <i>kutki</i> , <i>til</i> and <i>jagni</i>	31,070
<i>Betul District.</i>	
<i>Bardi</i> soil, a red gravel thickly strewn with reddish stones of a fair size. Sometimes it is free of stones and at others full of yellow flints. It grows <i>juari</i> and <i>tilli</i> with millets but must be fallow frequently (page 9, Settlement Report)	330,982
<i>Nagpur District.</i>	
<i>Bardi</i> soil, a red gravel soil covered with boulders found on the summits and slopes of trap hills	71,752
<i>Bhandra District.</i>	
<i>Bardi</i> soil, a very poor gritty soil, sometimes composed of the detritus of laterite	24,017
<i>Balaghat District.</i>	
<i>Bardi</i> soil, a very poor stony soil, red or yellow in colour, rarely found below the ghâts	1,736
<i>Ohanda District.</i>	
<i>Khardi</i> soil, a very poor soil of light colour and full of stones. It grows only <i>til</i> and <i>juar</i> : requires plenty of manure and frequent resting	29,726

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Bilaspur District.

	Aores.
<i>Bhata</i> soil, an inferior soil found on the ridges. It consists of a light springling of sandy soil over grayol. It will grow nothing but <i>sosamum</i> and the lightest kinds of millet : in consequence, it is largely left uncultivated.	12,990
TOTAL	1,205,789

ANNEXURE II.

Letter from Mr. G. Evans, Deputy Director of Agriculture, Central Provinces, to Mr. E. L. Glass, Executive Engineer, dated 21st September 1917.

Rainfall and cold are two factors in successful cotton growing. A rainfall of 25-35 inches is all right for cotton. A rainfall of fifty inches or over is fatal even on well-drained land.

We tried Cambodia and *buri* cotton at Adhartal for several years in succession with absolutely no success. If grown as a rain crop, the cold in November and December kills the young bolls before they are ripe.

We then tried growing the crop by sowing in April and May and irrigating it until the monsoon came. We had slightly better results, but it was not a paying proposition.

We got one picking in October, but this was usually badly damaged by late rains and the later pickings were all ruined by cold nights.

In the northern parts of the Central Provinces, therefore, I think there is little scope for long staple cotton under irrigation. The heavy rainfall and the cold weather which is much more acute than in the Chhattisgarh side are fatal.

Letter from Mr. D. Clouston, Officiating Director of Agriculture, Central Provinces, to Mr. E. S. L. Beddy, Superintending Engineer, dated Nagpur, the 14th September 1917.

Cotton grows beautifully on *bhata* soil in Chhattisgarh and fairly well on the *wardi* soil of Chanda. In the light *sehar* soil of Balaghat it has not been tried so far. The difficulty experienced by us in growing it on *wardi* soil in Chanda was that it required weeding when the people were busy with their rice, that is in say, from July till the end of August. On *bhata* soil, curious to say, extraordinarily few weeds come up. The soil gets so hot and dry in the hot weather that the weeds are killed, it would appear. Cambodia, a long stapled cotton, gave an outturn of 783 lbs. of *kapas* worth approximately Rs. 170 last year on *bhata* land on the Chandkhuri Farm. On the Sindewahi Farm, the same cotton has given from 600 to over 1,000 lbs. of *kapas* (unginned cotton) on *wardi* soil.

(2) To sum up, I should say, that the prospects of growing any considerable area of long stapled cotton on light soils in Chanda, Balaghat or Bhandara are not very bright because of the difficulty of finding labour for weeding during the rice season. On the *dorsa* (black) soil of the Tharsa farm we have got yields of from 500 to 600 lbs. of *kapas* per acre under irrigation ; but on black soil of the type found over most of Nagpur District, the outturn is not increased to any appreciable extent by irrigation.

(3) How far it will pay to grow cotton in the rice tract is an economic question which time and experiment will solve. I am very hopeful regarding Chhattisgarh because weeding there is not a formidable difficulty.

III.—North-West Frontier Province.

Mr. F. W. CARNE, Secretary for Irrigation, North-West Frontier Province.

EXAMINED AT LAHORE, JANUARY 1918.

Written statement.

VI.—IRRIGATION.

3149. (50) Experience.—Since joining the Public Works Department Irrigation, at the end of 1887 I have spent most of my time on the open canals of the Punjab. I came to the North-West Frontier Province in May 1915. I have had the usual experience of a Canal Officer in canal irrigation assessment work.

3150. (51) Wheat *versus* cotton.—I think that cultivators much prefer wheat to cotton. Northern India is not very suitable for cotton, especially sandy soil localities. There is more export business in wheat than in cotton. Wheat is much less troublesome to cultivate.

3151. (52) (a) Critical period in regard to water supply.—The critical period everywhere is, I should say, in September—October, when water is required for maturing the standing *kharif* crop and for starting the *rabi*, i.e., giving the land water for sowing. If the cotton area were increased, there would become a diminution in the wheat area.

3152. (52) (b) Watering of cotton.—I believe that experiments for a cotton crop, as carried out for a wheat crop, have not yet been carried out. I have no reliable information on this point.

3153. (52) (c) Statistics.—Details for the Lower Swat Canal have been given by Mr. Burkitt, Executive Engineer.

3154. (53) (a) Possibilities of expansion of area under cotton by enlargement of canals.—There is but little room for expansion in the manner suggested, because the monsoon ends by the 20th September at latest, and on its cessation, the fall of a river is rapid and usually there is very little water to spare at the critical time in September—October.

3155. (53) (b) Effect of enlargement of canals on area under wheat.—Such expansions would reduce the area watered for sowing wheat because the cotton area would be increased, but there would be no increase in the river supply to make up for this.

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Mr. F. W. CARNE.

[Continued.]

3156. (54) (a) Improvement in duty of water by remodelling of outlets.—As up to the present in this Province, there has been no real shortage of water, it has not been necessary to make any serious attempt to improve the duty; this will naturally follow now that the Upper Swat Canal is also taking water and in this way from the same river supply, two imperial canals, instead of one will be supplied.

3157. (54) (b) Utilization of modules.—Modules or semi-modules will no doubt be of great use in equalizing the distribution of supply between the upper and lower outlets on distributaries.

3158. (54) (c) Effect of remodelling of onlets in irrigated area.—This can hardly be predicted at present in this province. There would be an increase in the *rabi* crop, chiefly wheat.

3159. (55) Fluctuations in river supplies and their effects.—The increase in the spring is gradual. The decrease in the autumn is somewhat sudden. I do not think this influences the cultivators in their choice of a crop in any way whatever.

3160. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—Certainly wells could be utilized of the sowings and final waterings of cotton would be feasible on the Paharpur Canal, but to a small extent only as the supply arrives late and stops early. I have experience of American cotton; and do not know its requirements but, according to the note given, river water would not be available in time in the spring and is likely usually, to stop short too soon in the autumn, so the extra area, due to the utilization of wells, would be likely to be small. It would be fairly simple to give waterings from wells to a considerable area but water in sufficient quantity for sowing would be the difficulty.

3161. (56) (b) Extension of irrigation under wells in canal areas.—Mixed irrigation is only likely to be feasible on the Paharpur Inundation Canal. There are large well areas in the Upper Swat Canal Tract, but if this area were to be put under canal irrigation, the wells would go out of use. Mixed irrigation would not, I think, be practised.

3162. (56) (c) Tube wells.—I have had no real experience of tube wells, but I do not think that they would be of much use, as they are only likely to be used in places where there is no canal irrigation, and in connection with and supplementary to ordinary wells.

3163. (56) (d and e) Construction of weirs *versus* construction of wells.—The construction of weirs is possible in the case of the Imperial canals in only one case, namely the Paharpur Canals. If this could be made perennial, there would be a great improvement in the irrigated area. In the case of the Paharpur Canal the construction of a weir is under consideration. Increasing the number of wells seems to be a practical difficulty, because they would have to be worked by bullocks, necessitating an increased area under fodder crops, thus to a great extent defeating the end in view. In the Paharpur Canal tract there is also trouble on account of river floods and torrent floods rendering wells liable to destruction.

3164. (58) Cropping and causes affecting it.—On the old canals in this Province, I do not think that the available supply has anything to do with the choice of crops grown. I cannot give any opinion in this matter about the Upper Swat Canal as the irrigation in parts is developing very slowly. In any case *kharij* must be affected by the necessity for fodder crops.

3165. (64) Suitability of water rates.—In this Province, the water rates charged have no effect in the cultivators preference for a particular crop. In this Province, higher rates than at present levied are required in order to make the Upper Swat Canal pay and to enable any new schemes to be taken up.

Mr. F. W. CARNE called and examined.

3166. (Mr. Ashton.) There is practically no area under cotton on the Upper Swat Canal at present. We have not fully developed irrigation on this canal as yet. On the Lower Swat Canal, it would be possible to extend the area under cotton. Mr. Burkitt has said in his written evidence that "since we irrigate cent per cent of our commanded area annually, an increase in the area under cotton would mean an identical decrease of the area under wheat." That is practically true. We get a sufficient supply to irrigate cent per cent in the North-West Frontier Province as against from 33 to 70 per cent in the Punjab. The area already irrigated is therefore practically the whole commanded area.

3167. There is no hope of a further increase on the Paharpur Canal unless we can make it absolutely proof from breaching by cross drainage flow which we are trying to do at present but the people down their want *rabi* irrigation. They are not very keen on *kharij* irrigation. We cannot give them a *rabi* supply at present. They get a lot of irrigation by flood water and the canal water is therefore more or less superfluous. They could perhaps be induced to extend their wells and thus secure irrigation. There are a few wells already but I am not certain whether they grow cotton under well irrigation. They probably do so but the people down there do not appear to be very keen cultivators. They only grow enough cotton to supply local needs at present. No cotton goes out of the Dera Ismail Khan District into other parts of India. It is all taken away by the border people. If the area under cotton were increased, it would go over the border and would not come to India. Colonel Blakeway, Revenue Commissioner, says in his note that a certain amount goes to Karachi when the rates are good enough but the majority of it goes to Kabul through Peshawar. The border tribes are dependent on the North West Frontier Province to a great extent for supplies as their own country does not provide much. Any surplus would, I think, go to the trans-frontier tribes and to Afghanistan rather than anywhere else. There is no great demand for cotton. Wool would appear to be more important than cotton.

3168. (Mr. Roberts.) There are prospects on the Upper Swat Canal for cotton. Irrigation has only recently started. We have not had much *kharij* irrigation so far. On the lower parts of the Upper Swat Canal, I do not think there will ever be any cotton. That is the *maira* area, which consists mostly of very sandy soil and the Agricultural Officer has already given a very poor opinion of the soil. There are also other difficulties. The coarse grass will have to be removed; the ground will have to be terraced and the water course may have to be lined. Development in this tract is likely to be very slow indeed. Besides there are no villages at present; the villages are situated in the tracts where there are wells and the villagers have sometimes to go as far as five or six miles to get to this *maira* land. The Civil Department is trying to induce land owners to construct hamlets. It will not be possible to develop the tract as quickly as it would have been if the land had been Crown land. It is all private land and the land owners have large areas of good soil watered by wells so inducement is necessary to get them to take to irrigation or the areas of poorer soil in the *maira* tract. It has been suggested that Government should buy up all the land and then let it out but the Civil Department would not accept that idea. If the land could be bought

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Mr. F. H. BURKITT.

up and relet the whole tract could probably be developed quickly. The upper part of the tract under the Upper Swat Canal has no such disadvantages. There we are getting a good deal of *rabi* irrigation. We are not likely to get as good *kharif* irrigation because the conditions are not so favourable. I think the country, in general, is not particularly suitable for cotton but part of the Peshawar Valley is famous for good cotton.

3169. Only about two per cent of the cultivated area of the province is under cotton. For the last two years it has been only one per cent indicating that there was not much demand for cotton. There has been a good deal of unrest since 1915. Developments have been delayed on account of political troubles which have affected the Upper Swat Canal.

3170. We would like to make the Paharpur Canal perennial. We might then be able to extend the canal and so make it pay. We do not see any hope of this just at present. It is very difficult country. It has a steep slope and is very much cut up by floods from the hills. A perennial canal utilising the existing Paharpur Canal could not command the whole area between the hills and the river. It could only command a very narrow strip. To make a real paying project the canal would probably need to go right away down to Jacobabad. The scheme for making the canal perennial is hung up for the present. There was a proposal to make it perennial by canalising the Bilot Creek of the river Indus. Recently there have been changes at the head of the Bilot Creek and it is silted up. I do not know whether our former idea of making the canal perennial has been rendered absolutely impossible but it does not appear practicable at present. The Paharpur canal is now in rather a precarious condition. There are wells in the canal area many of which are close to the canal. On the right bank, floods come down and make cultivation precarious in the *kharif*. Cultivators would do *rabi* irrigation if they could get the water. The inundation supply does not commence till May and is not much good for the *rabi* unless it is supplemented by wells because the canal supply stops early in the autumn. The Deputy Commissioner of Dera Ismail Khan was asked about the prospects of extending irrigation below Dera Ismail Khan; he said he was not very hopeful because the cultivators were such a poor lot and the land would have to be colonised. My predecessor proposed to extend the canal a short distance only below Dera Ismail Khan and to make it perennial. At present it is a small canal only discharging about 600 cusecs. As the upkeep of this canal is so troublesome and it does not pay we should like to hand it over to the Civil Department, but I do not think they would care to take it over.

3171. There are many canals under the jurisdiction of the Civil Department. There are such canals in the Peshawar, Hazara, Kohat, Bannu and Dera Ismail Khan districts. They are under the Deputy Commissioners. The Canal Department has jurisdiction over the Upper and Lower Swat Canals and the Kabul River Canal.

3172. (Mr. Henderson.) I cannot say whether the land in Dera Ismail Khan is good cotton land or not. I have only been on the Paharpur canal two or three times and do not know the District. At present the ground is so subject to floods from the hills that cultivation is rather a precarious business. The land between the canal and the river might be made safe if we can make the canal proof from breaches by torrent floods. The water would then not spread out so much over the country. The country between the canals and the hills can not be protected in that way. I do not know if there is a very large area for the extension of the cultivation of cotton. Torrent flow irrigation is done by *bunds*; the *bunds* break and deep ravines are made in the land. Then a new site for a *bund* has to be selected. This system of irrigation spoils the land. It is a very difficult business. In fact, the trouble from these torrent floods was so acute during the Waziristan expedition in 1917 owing to floods coming across the Tonk road that a Committee sat in December 1917 at Dera Ismail Khan to settle what could be done as transport was held up for days in going between Dera Ismail Khan and Tonk. The idea was to try and reduce the overflow of floods in the Gomul river in order to protect the road. Incidentally that would help considerably in the case of the Paharpur canal. The proposals will not only safeguard the road but also help the cultivators. Until such torrents can be more effectively controlled, irrigation will be too precarious for valuable crops.

3173. (President.) I am not very hopeful of any alteration in the general character of agriculture, the conditions of the province being so peculiar. Except round about Peshawar there are no facilities for manufactures; there are no ginning mills except in Peshawar.

3174. There is no colonization scheme on the Upper Swat Canal. The land is all privately owned. The only Government land, I believe, consists of the forest *rakhs* on the Paharpur Canal. We give water to these *rakhs*. They are close to the canal, i.e., between the canal and the river. There is nothing valuable there in the way of timber at present. These *rakhs* are used for grazing at present. Those small areas could be colonized but I am not very optimistic about it.

Mr. F. H. BURKITT, Executive Engineer, Lower Swat Canal Division, North-West Frontier Province.

EXAMINED AT LAHORE, JANUARY, 1918.

Written statement.

VI.—IRRIGATION.

3175. (50) Experience.—I have had fourteen years' experience of irrigation in general and also of irrigation under canals. I have had eight years' experience of canal irrigation assessment work.

3176. (51) Wheat versus cotton.—Cultivators prefer wheat to cotton for the following reasons:—

- (a) Great wheat consumption for food inside the Province.
- (b) For the last ten years, the price of wheat has been high while that for cotton has been variable.
- (c) Wheat can be stored for long periods.
- (d) In this Province, on canal land, heavy rain, if it occurs, greatly injures the cotton crop; the latter grows to stalk and yields little cotton.
- (e) The method of sowing wheat is easier than for cotton; it can be rapidly sown on large acres, and every *zamindar* is expert in the method.
- (f) In the case of *barani* (unirrigated) crops, wheat does with two or three good falls of rain while cotton requires five or six.

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Mr. F. H. BURKITT.

[Continued.]

(g) In this Province, wheat is harvested just when labour is most plentiful. Cotton, on the other hand, takes a long time to harvest and it requires a lot of weeding when labour is not available. The expenses of labour are about one-fifth of the value of the cotton crop.

3177. (52) (a) Critical period in regard to water supply.—The critical periods on the Lower Swat Canal and on the Kabul River Canal are April, September and October. There would be less trouble if the cotton area were increased between April and October.

3178. (52) (b) Watering of cotton.—The cotton is watered in June, July and August, and the volume of water required is one-quarter cusec per acre per watering.

3179. (52) (c) Statistics.—A separate statement is attached (Annexure I) which gives statistics in the case of a typical distributary on the Lower Swat Canal.

3180. (53) (a) Possibilities of expansion of area under cotton.—The supply in the rivers would be sufficient for a large expansion of the area under cotton during June, July, August and September. The area under wheat would be diminished.

3181. (54) Improvement in duty of water by remodelling of outlets.—A ten per cent. improvement could be effected. Modules could be used most effectively. No additional area would accrue without pumping.

3182. (55) Fluctuations in river supplies and their effects.—The increase is gradual in April and the decrease sudden in September. There is no effect due to this state of affairs; more wheat could be grown if the supply lasted longer in September and October.

3183. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—In cases in which canals carry a supply for irrigation during the summer months only, it would be possible for the sowings and final waterings of cotton to be carried out by irrigation from wells. A combination of wells and canals would be feasible in the part of the Dera Ismail Khan district irrigated from the Paharpur Inundation Canal.

3184. (56) (b) Extension of irrigation under wells in canal areas.—There are very few wells in the tracts served by perennial canals, but there are numerous wells in the area served by the upper reaches of the Paharpur Inundation Canal. The population is, however, too sparse to permit of an extension of wells here unless colonists are introduced.

3185. (56) (c) Tube wells.—I have no personal experience of tube wells, but one is used in combination with an outlet from the Paharpur Canal. Their use would be very valuable in this connection in the Dera Ismail Khan district.

3186. (56) (d) Construction of wells.—There is only one canal which could be improved, *viz.*, the Paharpur Canal. The question of making this perennial is being considered. If this improvement in the Paharpur Canal is feasible at all, it will be both cheaper and quicker than the construction of tube wells.

3187. (57) Effect of enlargement of canals on revenue.—With the present rates in force, an increase in the cotton area would mean no increase in revenue as the rates for cotton and wheat are the same, and, since we irrigate one per cent of our commanded area annually, an increase in the area under cotton would mean an identical decrease of the area under wheat.

3188. (58) Cropping.—The following figures give the distribution of crops on an average holding of 100 acres:—

<i>Kharif.</i>										
Sugarcane	.	.	.	.	.	.	.	.	.	6
Vegetables.	.	.	.	.	.	.	.	.	.	4
Cotton	.	.	.	.	.	.	.	.	.	8
Maize	.	.	.	.	.	.	.	.	.	15
Fodder	.	.	.	.	.	.	.	.	.	5
Miscellaneous	.	.	.	.	.	.	.	.	.	8
TOTAL										46
<i>Rabi.</i>										
Wheat	.	.	.	.	.	.	.	.	.	29
Barley	.	.	.	.	.	.	.	.	.	10
Millet	.	.	.	.	.	.	.	.	.	1
Fodder	.	.	.	.	.	.	.	.	.	8
Miscellaneous	.	.	.	.	.	.	.	.	.	2
TOTAL										50

ANNEXURE I.

Statement showing discharges and areas of different crops month by month in the case of a typical distributary of the Lower Swat Canal.

January	.	.	.	.	.	.	.	.	.	95
February	.	.	.	.	.	.	.	.	.	33
March	.	.	.	.	.	.	.	.	.	124
April	.	.	.	.	.	.	.	.	.	120
May	.	.	.	.	.	.	.	.	.	169
June	167
July	176
August	115
September	134
October	100
November	84
December	95

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Mr. F. H. BURKITT.

[Continued.]

ANNEXURE II.

Average monthly area of each crop.

	KHAIR.						RABI.				
	Sugar-cane.	Rice.	Cotton.	Maize.	Folder.	Miscellaneous.	Wheat.	Barley.	Mustard.	Clover.	Miscellaneous.
January . . . . .	..	..	..	..	..	..	7,430	8,223	643	1,036	6,183
February . . . . .	..	..	..	..	..	..	7,446	8,246	643	1,042	6,193
March . . . . .	..	..	..	..	..	..	7,416	8,246	643	1,042	6,188
April	2,126	..	62	..	..	1,305	..	..	..	..	..
May	2,403	2	1,856	5	23	4,234	..	..	..	..	..
June	2,490	2	2,150	7	84	6,159	..	..	..	..	..
July	2,400	2	2,157	1,293	348	8,082	..	..	..	..	..
August	2,400	2	2,157	5,455	584	8,430	..	..	..	..	..
September	2,490	2	2,157	5,335	670	8,488	..	..	..	..	..
October	2,499	..	..	..	..	..	1,430	1,094	59	610	2,215
November . . . . .	..	..	..	..	..	..	4,237	2,840	191	997	3,885
December . . . . .	..	..	..	..	..	..	10,098	7,303	611	1,831	5,661
The maximum carrying capacity of this distributary is 210 cusecs.											

Mr. F. H. BURKITT called and examined.

3189. (Mr. Ashton.) On the Kabul River and Lower Swat Canals, the most popular crops are the *rabi* crops of wheat and barley; which are about equally divided. In the summer they have sugarcane, Indian corn and *juar*. A little bit more than cent per cent of the commanded area is irrigated. There is some hope of replacing maize by cotton provided you get a better market for cotton. The people live largely on maize and they have to grow a large amount of maize on that account. They would certainly give up maize if they could get a better market for cotton. The cotton that is produced is used mostly for local consumption. There is one ginning factory in Peshawar and a certain amount goes there.

3190. There is any amount of water from May till the beginning of September. April is a very variable month, you may have enormous supplies and, on the other hand, you may be pretty short of water till the end of the April. October is a dry month. The river is distinctly falling in that month to winter conditions. As it is, we are short of water since the Upper Swat Canal started. There will be a great shortage of water in the winter. I do not think that this shortage of water will have any effect in gradually reducing the area under wheat because we shall be able by rotational turns to work it all in and also there is a large number of district canals there, which, at first, will require a lot of water. We shall gradually cut them down to less and less and improve the canals.

3191. There is always plenty of water in the Kabul River Canal which irrigates the right bank of the river. The only appreciable way of extending cotton in that area is by pumping from the canal in the new area. It could be done hydro-electrically. The area that would come under cotton in this way would depend on how much capital was put into the scheme. It is a matter of working out the cost. I have half worked out a small scheme. I think it provided for about 10,000 acres at an expense of two lakhs of rupees. There is no limit to the amount we could pump if we spent enough money. I presume the present water rate would be charged. When funds are available, it would be worth while to make a detailed estimate.

3192. On the Lower Swat Canal, cotton is watered in May—not before May. The sowing of cotton would clash with the harvesting of wheat. The harvesting of wheat is very troublesome there, so much so, that some *zamindars* have gone in for reaping machines owing to the scarcity of labour. If more reaping machines were used, the labour employed in harvesting of wheat could be employed on cotton. We have a very slack demand for water in April. The Upper Swat Canal is only just starting but the conditions there will be exactly the same as on the Lower Swat except that the Upper Swat Canal tract will be a drier tract than the Lower Swat. A good deal of land on the Lower Swat is waterlogged and the cotton is not good there. It would certainly be feasible to substitute pumping for flow irrigation in the waterlogged tract. No scheme has been worked out because it could not pay from the Departmental point of view.

3193. If the Paharpur Canal were made perennial, there would certainly be hope of extending cotton there. It might be made perennial but the trouble is that the cultivators are very backward and very lazy and there is very little hope of that canal making a good show until we have a better type of cultivators. The Paharpur Canal could be made perennial by canalising the Bilot-Creek, but the slope of the country is very bad. The canal practically runs parallel to the Indus. At the head you are away four or five miles from the Indus and further down the river it is again within two or three miles. Even if it were extended further, unless it went down far into Sind, it would never command a big area. It is not a promising scheme. I think we shall make it flood proof in time. It would be possible to take out a canal from the right bank of the Indus near Kalabagh above the weir surveyed for the Thal project but it would require a fifteen mile marginal *bund* in the river costing something like two lakhs of rupees and there would have to be 200 miles of main line before you could get any big area for irrigation under it. The cost would be enormous and the water rate necessary to make it pay would be so high as to be prohibitive.

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Mr. W. B. HARVEY.

3194. The tract under the Lower Swat Canal is very thickly populated but the population on the tract under the Upper Swat Canal is very sparse and that is one of the great troubles in extending irrigation at present. We cannot get the population.

3195. I am going to put in Harvey's modules on a distributary, the Hazar Khani branch. We expect that ten per cent. improvement will be effected by doing so. If successful, the use of the modules will be extended. We are putting them in but more with the object of washing out loss that will be caused by the Upper Swat Canal coming into full operation. We cannot do any more irrigation; we are irrigating our full area now.

3196. I do not think there is any hope of the extension of tube wells in the Dera Ismail Khan tract irrigated by the Paharpur Canals as a Government concern. There is certainly none at the present water rate. Tube wells would not give Government a sufficiently big profit. If the area in which the tube wells were installed were under the canal, it would mean that so long as the canal was flowing, the pump would be out of use and there would merely be a saving of fuel. Tube wells and pumps could be made to pay by themselves only in parts which were not touched by the canals. There are a few big Hindu landlords around Dera Ismail Khan, the remainder are all small men. They are not likely to put down tube wells except in the near vicinity of Dera. In the Mardan Division on the Upper Swat Canal, the subsoil water varies at present from 120 to 170 feet below the surface of the canal, so it would be a big proposition to pump that height. There is no danger of waterlogging. The Upper Swat will never waterlog except in certain small tracts as the area it commands is intersected by tremendously deep nullahs.

3197. (Mr. Roberts.) On the frontier, the country is suitable for cotton growing except in waterlogged tracts. For the general development of the country as much water is required as in the Punjab. The conditions are the same as in the Punjab. We have an experimental farm near Peshawar, which has educated the cultivators to a certain extent. There is no farm in Dera Ismail Khan. That tract is very backward indeed, and it would be essential to get another type of colonist there. A good deal of agricultural work is necessary alongside the provision of irrigation. As to the political aspect, colonization from the Punjab would not be liked at the present time. The only hope would be immigration from the trans-frontier tracts but the transborder people are very bad cultivators with the exception of the Mohmands. In the cold weather we can get to Dera Ismail Khan practically in a night but in the hot weather it takes a day and a night as the river has to be crossed. Then there is a journey of forty miles up the canal in a boat to get to the headworks. It is very difficult to control from Peshawar. I consider the tract capable of a good deal of improvement provided the right type of men as well as sufficient water could be obtained. It is a vast plain untouched right up to Tonk. We could not do much except by well irrigation. There was a scheme to dam the Gomal, but the last Inspector General of Irrigation condemned it as he said it would silt up in 25 years.

3198. (Mr. Henderson.) I know of no other way of coping with the torrents which come down in the Dera Ismail Khan tract except by making a marginal *bund*, at some distance from the mountains with overflow weirs and sluice gates at intervals. It would be necessary to have fixed lines for drainages and fixed lines for distributaries. The velocity of the torrents is tremendous especially in the higher reaches and they also silt up tremendously. They are a very serious menace to the District. There would have to be a very *pukka* system of high flood embankments to keep them away from the canal. At present there is no natural drainage. If you could confine the *nullahs* to certain lines, then you might be able to do something.

3199. (President.) The only frontier tribe who are good agriculturists are the Mohmands. They have largely settled on the Lower Swat Canal which is quite close to their frontier. The people across the Delhra Ismail Khan border know nothing about agriculture. They would not be desirable residents on our side.

Mr. W. B. HARVEY, Executive Engineer, Mardan, North-West Frontier Province.

THIS WITNESS WAS NOT ORALLY EXAMINED.

Written statement.

VI.—IRRIGATION.

3200. (50) Experience.—I have about eight years' experience of irrigation on canals, not including service on construction of canals. I have experience of assessment of crops on the Lower Chenab and Upper Swat Canals.

3201. (51) Wheat *versus* cotton.—Wheat is generally preferred to cotton. The reasons given for the preference are—

- (1) Wheat is a food,
- (2) Wheat can be grown in practically any sort of land, which is not possible with cotton.
- (3) Less labour is required for wheat than cotton.
- (4) Double cropping is possible on wheat fields while a clover only can be grown with cotton.
- (5) Taking the straw into consideration, the profit per acre is greater on wheat than cotton.
- (6) Cotton is not as robust a crop as wheat.

3202. (52) (a) Critical period in regard to water supply.—The critical periods are spring and autumn. In the former season *rabi* crops require water for ripening the grain and the *zaid rabi* and *miana kharif* crops are being sown. In the latter season, *kharif* crops still require water and *rabi* crops are being sown.

3203. (52) (b) Watering of cotton.—Cotton is watered about four times, the first watering being given before sowing in April, and a second after the plants have germinated. Rain will reduce the number of waterings given.

3204. (52) (c) Statistics.—The channels in the Mardan Division, Upper Swat Canal, have only been running for two or three crops. Figures showing relation between areas irrigated and water used are not therefore of value.

3205. (53) (a) Possibility of expansion of area under cotton by enlargement of canals.—The Swat River falls suddenly about the end of August. The rice crop in the Swat Valley requires to be matured in September and October as well as the *kharif* crop on the canal. No considerable increase in the size of the

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Mr. S. WALKER.

canal appears, there, to be possible, since although there would be sufficient water up till August, there would be difficulty in maturing the crops in September and October.

3206. (54) (a) Improvement in duty of water by remodelling of outlets.—Provided equal distribution of water is ensured to all outlets on a distributary, the duty of water would be improved by forcing some to be more economical in the use of water and giving others a steady supply in place of a fluctuating supply. It is not possible to say to what extent, however, the duty could be thus improved.

3207. (54) (b) Utilization of modules.—In my opinion a module or outlet, which always discharges a supply proportionate to the supply in the channel at any time is what is wanted. Not a constant discharge module. Assuming it to be possible to give a proportionate supply to each outlet, as suggested above, further economy could be obtained by measuring the quantity of water entering the distributary at its head accurately by meter or otherwise, and basing the total demand in money for the crop on the distributary on this measurement. The actual areas irrigated would be measured, as at present, but the rates per acre charged would vary, depending on the quantity of water used by the whole distributary. An outlet which it is hoped will fulfil this purpose is under test at Mardan.

3208. (54) (c) Effect of remodelling of outlets on irrigated area.—On this canal it is doubtful if zamindars would increase the area under cotton for the reasons given in paragraph 3201. It is also probable that maize rather than cotton would be grown.

3209. (55) Fluctuations in river supplies and their effects.—The Swat River usually increases gradually in spring but decreases rapidly in autumn. The rate depends, however, on climatic conditions. The area irrigated up to date in this Division is small and the effect of the fall in the river in autumn has not yet been felt.

3210. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—There are a very large number of wells in this Division (Mardan). Tobacco, cotton, maize, and other crops are irrigated from these wells. It does not, however, appear practicable to combine canal irrigation with irrigation from existing wells. A feature of this canal is the number of falls varying from two feet and six inches to ten feet on distributaries.

3211. (56) (c) Tube wells.—It would not be difficult to sink tube wells at these falls and utilize the power at the fall to pump subsoil water into the canal and thus considerably reduce the supply of river water required without altering the size of channels. At the same time, the subsoil water level would be controlled.

3212. (58) Cropping.—The usual cropping adopted is shown below :—

		Acres.
Rabi	{ Wheat and barley	44
	{ Shafal, peas, etc.	22
Kharif	{ Maize	22
	{ Ohari, bajra, cotton, etc.	12
		100

Double cropping is, however, common.

3213. General.—Irrigation in this division is at present undeveloped and it is not possible to say whether the cultivation of cotton is likely to appeal to the cultivators or not.

Mr. S. WALKER, Executive Engineer, Malakand Division, Upper Swat Canal, North-West Frontier Province.

THIS WITNESS WAS NOT ORALLY EXAMINED.

Written statement.

VI.—IRRIGATION.

3214. (50) Experience.—My irrigation experience on canals is as follows :—

1901—07	Sirhind Canal.
1907—08	Western Jumna Canal.
1908—09	Lower Swat Canal.
1910—15	Construction.
1915—17	Upper Swat Canal.

3215. (51) Wheat versus cotton.—Cultivators prefer wheat to cotton as an irrigated crop for the following reasons :—

- Cotton requires special soil ; wheat can be grown on most soils.
- Wheat is less expensive to sow, cultivate and reap than cotton.
- Referring particularly to the North-West Frontier Province, the season for sowing is the same as in the Punjab ; the outturn is smaller than in the Punjab.
- Fields on which wheat is sown can be double cropped in the year, i.e., produce a *kharif* crop of another kind. Cotton takes more out of the land than wheat.
- Wheat is a staple food.

3216. (52) (a) Critical period in regard to water supply.—Referring to the Upper Swat Canal the critical period is 15th August, September and October 15th. Cotton requires a lot of water during the three months mentioned ; there would be danger of failure of cotton at present and until permanent works are instituted for diverting the river from the northern channel to the southern channel.

Punjab.]

Mr. G. C. LAURIE.

3217. (52) (b) Watering of cotton.—Cotton is watered on the Upper Swat Canal as below—

One watering before sowing (between 15th March and 31st May).

One watering two months after sowing.

Subsequently a watering every fifteen days up to 1st October (on the Upper Swat Canal as it is a new canal on an old canal).

The crop is over by the 15th October.

(2) An average of three inches for each watering, more for the first two waterings less for the others is required.

3218. (55) Fluctuations in river supplies and their effects.—Increases and decreases are generally gradual in the Swat River but vary greatly from year to year. The rest of the question does not apply to the Upper Swat Canal.

3209. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—It would no doubt be possible for the sowings and final waterings of cotton to be carried out by irrigation from wells but it would require a very large number of wells worked by the ordinary country methods. Cultivators would be unlikely to construct and keep up wells on a tract irrigated in summer only, for the purpose.

3220. (56) (b) Utilization of wells for irrigation of cotton in canal areas.—There are areas aggregating 39 acres only under well irrigation in the Malakand Division, Upper Swat Canal. The only other wells existing are village and wayside wells.

3221. (58) Cropping.—The usual cropping of a holding of 100 acres is 60 acres *rabi* and 40 acres *kharif*. The *rabi* is generally two-thirds wheat, one-third barley. The *kharif* is generally two-thirds maize, one-third other crops.

IV.—Punjab.

Mr. G. C. LAURIE, Superintending Engineer, Western Jumna Canal Circle

EXAMINED AT LAHORE, JANUARY 7TH, 1918.

Written statement.

VI.—IRRIGATION.

3222. (50) Experience.—I have had 25 years' service on Punjab Canals, out of which I have had more than ten years' actual experience of being in charge of Revenue work in divisions and sub-divisions and about six years in charge of revenue circles. I have had several years' experience of construction of canals and one year of secretariat work. During my service I have had charge of ordinary perennial canals including both perennial and *kharif*/distribution canals, and I have also had charge of inundation canals, canals classed as perennial but actually liable to closure during the greater part or even the whole of the winter on account of failure of river supply, and also canals fed during *kharif* only from a large reservoir. From the above it will be seen that I have had considerable experience of canal irrigation as practised in various forms in the Punjab, including assessment work. In my evidence, however, I propose, unless it is definitely stated to the contrary to base my evidence on the existing state of the irrigated area dependent upon the Western Jumna Canal in the south-east corner of the Punjab where I have spent the last 5½ years of my service. The evidence however holds good in general for the Sirhind Canal also which covers the tract next alongside the Western Jumna Canal area on its north-west borders where I spent the previous year of my service; and generally speaking it holds good for the whole of the Punjab.

3223. (51) Wheat *versus* cotton.—There is, in my opinion, no doubt whatsoever that the Punjabi cultivator prefers wheat as a crop rather than cotton. The reason for this is not difficult to see, inasmuch as his main food staple is wheat, and he feels certain that there will always be a large demand for it quite irrespective of the fact that he requires it for his own consumption. Cotton, on the other hand, is liable to considerable fluctuation in price, and the crop itself is much more liable to damage from insect pests, short supply of water, or excess of rain than is the wheat crop. I have enumerated the three principal causes for liability to poor return from a cotton crop, and if the crop escapes from all three of them it is still liable to give a poor return by low ruling price of cotton when the crop comes to maturity. The cultivator, therefore, considers the wheat crop as one which will give him less trouble in maturing, not being so subject to insect pests, and not likely to be damaged by excess rain, as it is grown in the period of small rainfall, and more likely to give him a reliable profit. The areas of these two crops on all canals in the Punjab for the last two years for which statistics have been published are—

	1914-15	1915-16.	1916-17.
	Acres.	Acres.	Acres.
Wheat	3,377,770	3,041,248	Not yet published
Cotton	1,069,676	473,193	Ditto.

and on the Western Jumna Canal alone, the areas of principal crops have been—

	1914-15.	1915-16.	1916-17.
Wheat	261,795	323,111	309,967
Cotton	232,230	103,221	93,115
Sugar-cane	65,754	69,107	61,555
Grain	91,608	68,624	69,726

The wheat figures in the above include barley and also mixtures of wheat and grain, or wheat and other subsidiary crops. The reason for the decrease in cotton area in 1916-16 and 1916-17 was owing to failure of the river supply in the latter year, and to disinclination to put down the crop in 1915-16 on account of low price

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[Continued.]

for cotton ruling then. The reason for the low area of wheat in 1914-15 was not owing to the extra large area of cotton that year, as the total culturable area on the canal is 2,315,077 acres, so that ample area remained for putting down wheat, but it was owing to heavy rainfall late in September and also good rainfall in January, February and March which enabled an extra large percentage of the wheat crop to be put down and matured without assistance from the canal. The above reason also shows another point which makes the cultivator prefer a wheat crop to a cotton one, for, in a favourable year, he can obtain a good wheat crop without assistance from the canal and thereby save the whole of the canal water rate, but with a cotton crop he could never do this, or at any rate he could never get a good cotton crop by so doing though with luck he might get a moderate crop. The irrigated wheat crop in an average year only represents about half the crop and in a year of favourable rainfall it represents considerably less than half the crop. The irrigated cotton crop, on the other hand, represents almost the whole of the crop. It will thus be seen that the preference for wheat rather than cotton is very considerable.

3224. (53) (a) Possibilities of expansion of area under cotton by enlargement of canals.—In considering the question whether the cotton crop is likely to increase if the canal is enlarged, there are three principal points to be investigated—

- (a) Is there water in the river at the critical periods sufficient to permit of this ?
- (b) If so, is it worth while to enlarge the canals so as to utilize this surplus ?
- (c) Is there labour available for ploughing for cotton crop in addition to harvesting the wheat crop at the same time ?

As regards the Western Jumna Canal, the supply in the river during the critical periods of September, October, February and March is, one may say, usually short of demand, so that there would be no advantage in enlarging the canal, but, on the contrary, a distinct disadvantage inasmuch as it would be increasing the loss by percolation and also decrease depth of water in the canal and thereby necessitate constant heading up so as to get water into distributaries, and this of itself is exceedingly detrimental to good irrigation results by upsetting regulation and the distribution of water. It would also be useless to enlarge the canal without also enlarging the distributaries, inasmuch as the canal is made to correspond with the requirements of the distributaries, and the same loss of command and interference with good distribution would again take place in the distributaries. The canal, as it exists, and this statement also holds good for all canals in the Punjab in general, is designed to take the maximum supply which it can be at all safely expected to get from the river in an average year during the critical month of October and also to such dimensions that the river will supply, on an average, a half supply throughout the short supply period of the year from December to March both inclusive. Any enlargement of the canal to greater dimensions than given by the above would in the long run be detrimental, although undoubtedly in some years it might be beneficial. As a matter of fact, however, when the supply available in the river during the critical period is higher than the discharge allowed for in designing the canal, it generally coincides with periods of poor demand owing to the very same reason, namely, recent rainfall, and therefore again there would be no advantage gained by enlarging the canal. Inspection of canal supplies for the last six years gives the following information on this point. In 1912, river supply could only give less than half supply for canal throughout February, March, April and May; indent was never met till beginning of July and supply failed again from middle of October. In 1913, river supply could only give half supply throughout February and March and although higher in April and May, the indent was never met and often the supply was far short of demand; indent was complied with more or less throughout June, but demand was not high, and even then there was seldom surplus water; supply failed in the middle of September. In 1914, supply in the river was very short throughout February and March, and though indent could generally be met during April and early May, there was no surplus in the river up to 10th May; owing to rainfall, the October supply was good and the demand was very small throughout the month and never failed till the last week of November. In 1915, owing to rainfall in February and March, demand was low throughout and supply in river surplus, indent was moderate only in April and was usually met though there was usually no surplus in river; supply in river rose in May and gave surplus water, but failed again on 22nd October. In 1916, river supply was exceedingly short throughout February, March, April and May, and never rose till second week in June; supply was ample in October owing to rainfall and never failed till 20th November. In 1917, supply was very short throughout February, March, and April and indent was never met up till the latter half of May; supply was ample throughout October and November owing to rainfall, but demand was very small indeed and the canal several times remained closed; supply in river fell below full supply of the canals from beginning of December, but owing to low demand the indent could still be complied with. It will thus be seen that, on the Western Jumna Canal, there is no scope for increasing area of long-stapled cotton by enlarging the canal, inasmuch as in the critical months of February, March, April and October there is, as a rule, no surplus supply in the river; on the occasions when there is surplus supply available there would also be no advantage gained inasmuch as demand is low owing to recent rainfall and the canal is already capable of carrying further supplies if required.

(2) It is stated that the "long stapled cotton" requires water for preparation of the fields in February, for first watering between March 25th and May 5th, and for a heavy watering in October, in addition to intermediate waterings. It will be seen from the above that, in almost every year, these waterings would clash with waterings required for the wheat and that, as above stated, the wheat would be given preference. When water was available in early April, there would probably be a shortage of labour for ploughing and sowing owing to harvesting of wheat and barley in progress, and in the late April and early May, when wheat no longer required water, there would always be a shortage of labour owing to harvesting of wheat in progress. This shortage of labour is so great that it is with great difficulty and only by paying exorbitant rates that any canal work can be carried out during the period. As regards supplies during the period, May to September both inclusive, there is generally a surplus in the river, though, throughout May 1916, the supply was very short; during this period it is very seldom that the canal runs full supply of 6,430 cusecs, in fact, it only carried over 6,000 cusecs on nine days as the average of the last five years during this period as against 153 days in the period; the canal is capable of carrying increased supplies therefore during this period without enlarging it. To sum up then, there is usually no excess of supply in the river in February or March and often also not in October to enable large extra areas of cotton to be irrigated, and there would therefore be no gain in enlarging the canal; on the contrary the enlarging of the canal would be detrimental to the wheat crop which is the more important crop and is likely to remain so; even when water is surplus in the river available for this purpose in February and March, there would usually not be any labour available for ploughing and sowing in April.

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[Continued.]

3225. (59-63) Lining of Canals.—The question of lining canals, however, is on a separate footing altogether. Here we do not require to obtain a greater supply from the river. With lined canals, we eliminate a very large percentage of the heavy percolation losses in the canal channels which, under existing circumstances are purely wasted. In any new canal projects, the question of the advantage of lining the channels should undoubtedly be considered. The subject is largely a financial one, and I am unable off hand to say how the figures would work out. It would depend largely on the size of the canal, and the facilities for carriage of materials, and supply of water for masonry, and would vary largely with different projects. As regards existing canals in the Punjab, there are great difficulties in the way of now lining them, as closures can seldom be obtained and then only for short periods which cannot be definitely foretold beforehand. I think I am right in saying that recently at a canal closure on a certain canal over 10,000 men were collected for the work of lining and that they were able to work for about twenty days only and did little more than one mile of length of the canal and that, even in that length, the work was found to be unsatisfactory on account of the rush with which the work had to be done. On the Western Jumna Canal, winter closures have been possible only in the year 1915 during the last six years and then only for a fortnight once and ten days again later on, and it is evident that lining of the canal main channels could make very little progress. The bed of the main line is also below subsoil spring level for almost the whole fifty miles of its length, and lining the channel under such circumstances becomes further complicated and more costly. On the Western Jumna Canal, closures are made more difficult to obtain than on other canals in the Punjab owing to the very large percentage of the total area which consists of tracts where winter rainfall is seldom experienced, even when rainfall may be fairly heavy in more northerly tracts of the Punjab. It would therefore be exceedingly difficult to line the main channels and although it might be possible to line the distributaries it is doubtful whether this by itself would repay cost, as the principal source of loss is from the main channels. I have personally had very little experience of lining work, though I have carried out tank experiments and dealt with projects for lining channels and had charge of channels which had had experimental lining. The lined channels, which I have had charge of, were lined in the early days before much of this class of work had been done, and though they cost a lot of money to line, and the lining did good for a year or two, it soon lost its efficiency, and, finally, I believe, these linings were considered as having failed altogether. Except in very exceptional circumstances, I fancy that it would not pay financially to line distributary channels, though of course it might pay indirectly owing to increase in prosperity of the country. It might be useful to take up several average sized distributaries on the canal where irrigation has been fairly steady and see what increase of irrigation was got by lining them, the supply at head being kept as hitherto. It would be necessary slightly to enlarge the outlets in the head reach as well as to line the channel, as otherwise the tail outlets would gain the whole of the advantage. The question of lining of canals is, however, still under experiment in the Punjab. It is very easy to spend a very large sum of money on it, but most of the initial experiments have not turned out very successfully, and it is desirable to move cautiously in the matter. In most countries where irrigation is done, the canals belong to the persons who own the land, and under such circumstances the return on the cost of lining is considerably greater.

3226. (54) Improvement in duty of water by remodelling of outlets and use of modules.—The Committee raises the question of whether duty of water on canals can be improved by the use of modules and by equalising the distribution of the supply. There is no doubt that improvements can be carried out in this way, and, I think, I may say that the efforts of the Punjab Irrigation Department officers are unceasingly employed in dealing with these subjects. These subjects are, however, ones which do not specially concern cotton, but concern all crops on the canals; the improvements in this line are more likely to improve the wheat crop than the cotton crop, as the advantages will be obtained at the critical periods and throughout the winter, which are the periods of wheat irrigation, whereas during the greater part of the cotton season water is surplus.

3227. (56) Wells.—The question of wells is also one with which many other matters are concerned than the increase in the cotton area; wells usually exist in reasonable numbers where the depth of subsoil spring level is not too great, but where the depth is nearly 100 feet or in some cases even more than 100 feet as happens over a large percentage of Western Jumna Canal area, it is too costly to construct and to work wells for irrigation to any large extent, and the cultivators would rather migrate elsewhere if circumstances made it necessary for them to depend largely on wells. It is possible that by enforcing more dependence on wells in areas where spring level is high, we could obtain more canal water for sending on to areas where spring level is low; but this amount of interference with existing water rights would probably give rise to serious complaints owing to enhancing the cost of cultivation in the areas of high spring level. As regards the benefits to be obtained from the use of tube wells, I am not prepared to offer any opinion, but I fancy I am right in saying that they have not been found to be of much use in the Western Jumna Canal tract. Generally speaking, I think that if landholders were to increase the number of wells, the benefit from them would go more towards the wheat crop than the cotton crop, at any rate they would be used principally for maturing the wheat crop in spring though, possibly, the cotton crop might get the benefit from them in October, as there would still be hope of rain for ploughing for the wheat later on. The working of wells however means the upkeep of a large number of bullocks and these have to be fed throughout the year whereas for several months in monsoons and also at certain other seasons, there is very little work for them. In considering the question of irrigation of wheat or cotton by wells, one of the main points to be borne in mind is that if thirty acres of wheat depended on a well in the *rabi* season it would be sufficient to keep the well working steadily and give the various fields water by rotation of one watering every six weeks or even every two months; but in the case of thirty acres of cotton crop depending on a well, it would be necessary to give waterings at much shorter intervals in the event of no rainfall, and in the event of alternate periods of rainfall and drought the whole of the thirty acres would require the irrigation at one and the same time during the periods of drought. For this reason it will be seen that wells would be put down by cultivators more in connection with benefit to the wheat crop than to the cotton crop. As regards the values of these two crops on this canal, I see that the Department of Agriculture, Punjab, in statements in their Annual Report, give expected average outturn of unginced cotton (*deshi*) as 6½ maunds in Hissar, Rohtak, and Karnal Districts per acre of irrigated crop and normal value per maund as Rs. 7½; this gives average normal value of outturn as about Rs. 47 per acre for *deshi* cotton. Wheat, on the other hand, is entered as thirteen maunds average normal outturn and normal value per maund as Rs. 3-8-0 or average normal value of outturn as about Rs. 45-8-0 per acre. The difference is therefore slight theoretically and depends upon the ruling price per maund for the respective produce. The water rate charged was Rs. 4 per acre for other crop up to 1st April 1917, but from that date the rate for wheat has been increased to Rs. 5 per acre.

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[Continued.]

3228. (58) *Cropping and causes affecting it.*—The distribution of crops in holdings of 100 acres varies considerably with the soil and the quantity of the rainfall and the percentages of the area for which annual irrigation allowance is made. In an area where rainfall is scanty, as in the Hissar and Rohtak Districts, the cultivator has to arrange to grow enough irrigated fodder crops for the requirements of his horses and bullocks. In a tract in which rainfall is usually sufficient as in Karnal and Delhi Districts, he can arrange either to grow this fodder *barani* (unirrigated) himself or else buy it from other persons close by who do grow it *barani*. In the event of his deciding to do the latter, he can then put down a larger area of better class crops, sugar-cane, rice, cotton and indigo, in the hopes that, with the assistance of rainfall, his supply of irrigation water will bring all to reasonable maturity; in the case of rainfall failing, a certain number of these crops will probably fail as he will not, in all probability, be able to make the irrigation supply suffice for all, even if he can get assistance from one or more wells. If, however, the early rainfall fails, he will probably put down fodder crops at the earliest opportunity if rains are received later in the year, so as to obviate having to buy fodder at high rates. Taking an average holding on Western Jumna canal, for which fifty per cent. annual irrigation is proposed, the probable annual crops would be in a 100 acre holding as below:—

20 acres irrigated wheat,
5 acres *rabi* miscellaneous crops irrigated,
20 acres unirrigated wheat.
10 acres cotton,
5 acres sugar-cane or rice,
10 acres irrigated fodder crops,
5 acres irrigated oilseeds,
10 or 20 acres unirrigated fodder crop according to rainfall,
15 or 5 acres lying fallow throughout the year according to rainfall.

In light soil, gram would take the place of wheat, sugar-cane and rice. The distribution of crops is not much affected by the water supply, but more by the rainfall and the soil. For instance, where soil is very light, gram will take the place of wheat, and no sugar-cane or rice will be put down, but extra areas will be watered and ploughed over several times during monsoons in anticipation of sowing them with gram later on. The gram will, in fact, be approximately equal to or even greater than the areas given above for wheat, sugar-cane and rice; if wells are deep and not much used, possibly the area of fodder crops will be also less and their place also taken by gram as it will be unnecessary to provide for feeding bullocks for the wells. In years of heavy rainfall, the area of irrigated wheat and fodder crops will be less and the area of unirrigated crops correspondingly increased, and the area left fallow all the year round will decrease and be largely under wheat and fodder crops. In years of short water supply in the canal, the only difference would be a reduction in area of irrigated wheat and fodder and possibly, though not necessarily, a corresponding increase in unirrigated wheat and fodder; the produce of such crops per acre in a year of poor canal supply would however be poor, as if canal supply is poor, it necessarily follows that rainfall also has been poor. Poor rainfall in the preceding year increases the price of fodder and tends to increase the area of fodder crops put down in the next year. These differences therefore depend more on rainfall than on canal water supply. The cotton area, on the other hand, would usually be fairly steady, unless the area was interfered with by external matters such as fall in the price of cotton, or high price of seed; cotton, as a rule, is not grown dependent on rainfall, but on canal or well irrigation. I am not of opinion that the ordinary cultivator studies the subject of rotation of crops much, but he undoubtedly selects crops according to local soil, and will sow sugar-cane and rice in low damp site and wheat on higher ground.

3229. (52) *Watering of cotton.*—The first watering before ploughing for cotton crop requires to be a fairly deep watering, and, allowing four inches depth for this over the whole area, we obtain 14,620 cubic feet water per acre; considering, however excess depths given in some parts and loss in getting water from distributary head to the field, actual amount of water required at the distributary head is not less than 25,000 cubic feet water per acre. To this must be added loss between canal head and distributary head, and we obtain actual requirements at canal head as 28,500 cubic feet per acre of land to be ploughed, or, expressed differently, one cusec running for a day of 24 hours at the head of the canal will be sufficient for laying down three acres of cotton. In February and March, as above shown, this supply is with great difficulty obtained on this canal and circumstances are therefore not favourable on this canal for long-staple cotton requirements. In May and June, however, when required for *deshi* cotton sowing, the supply is more likely to be obtainable. The same state of affairs exists regarding the final waterings. As regards intermediate waterings, there is usually ample supply and no trouble is usually experienced. The periods at which watering is required are about once in three weeks, unless rainfall is received, but as a rule the number of waterings required is much reduced owing to frequent rainfall; the intermediate waterings require only about half the above amounts of water. I attach, as requested, a statement of statistics for two channels on this canal showing average flow, rainfall, and crop areas for the last three years; I regret that it is difficult to evolve much information from the statistics, but such as they are, they are given for information; the channels, for which the statistics are given, are fairly average in size and smooth in working and can be taken as representing the general working on this canal.

ANNEXURES.

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MR. G. C. LAURIE.

[Continued.]

ANNEX

Statement showing monthly flow of the Butana Distributary for

Butana Distributary . . . { Culturable commanded area
 Proposed annual irrigation . .
 Authorized full supply . .

	1914-15.														1915-						
	KHARIF.							RABI.							KHARIF.						
	April.	May.	June.	July.	August.	September.	TOTAL.	October.	November.	December.	January.	February.	March.	TOtal.	April.	May.	June.	July.	August.	September.	TOTAL.
Total of daily discharge	2,781	1,104	2,093	1,360	1,471	817	9,935	1,821	1,990	619	990	34	1,120	9,290	1,750	1,145	1,340	2,650	2,051	2,346	11,835
Total irrigation as per subsidiary statement (Annexure II.)	5,097	8,254	8,332	8,003	7,588	7,483	..	9,382	8,121	8,418	6,523	6,721	9,761	..	4,165	5,557	5,887	5,958	5,165	5,348	..
Rainfall . . .	0.0	0.9	0.52	11.05	4.1	9.0	..	..	..	..	2.2	2.2	1.0	..	..	..	1.1	7.6	2.45	4.4	..

ANNEX

Subsidiary statement showing monthly area of each principal crop irrigated

Channel.	th.	1914-15.															1915-								
		KHARIF.							RABI.								KHARIF.								
		Sugarcane.	Rice.	Cotton.	Indigo.	Maize.	Juar.	Miscellaneous.	TOTAL.	Wheat.	Barley.	Mixed Grain.	Sesoon and Toria.	Gram.	Sesaj.	Miscellaneous.	TOTAL.	Sugarcane.	Rice.	Cotton.	Indigo.	Maize.	Juar.	Miscellaneous.	TOTAL.
Butana Distributary.	April . .	2,275	..	2,894	..	1	..	827	5,997	..	..	..	..	..	..	..	..	2,208	..	1,100	225	..	30	596	4,165
	May . .	2,275	..	4,920	..	2	34	1,323	8,254	..	..	..	..	..	..	..	..	2,208	..	1,750	325	..	310	955	5,557
	June . .	2,275	..	4,028	..	2	104	1,323	8,332	..	..	..	..	..	..	..	..	2,208	..	1,750	325	..	640	955	5,887
	July . .	2,275	..	4,028	..	2	168	1,020	8,003	..	..	..	..	..	..	..	..	2,208	2	1,750	325	..	880	723	5,858
	August .	2,275	..	4,028	..	2	108	615	7,588	..	..	..	..	..	..	..	..	2,208	8	1,750	325	..	830	329	5,405
	September	2,275	..	4,028	..	2	108	410	7,483	..	..	..	..	..	..	..	..	2,208	8	1,750	325	..	836	212	5,348
	October .	2,275	..	1,928	..	..	..	110	4,913	415	0	110	4	1,400	..	410	2,360	2,208	..	505	..	..	..	02	2,895
	November	2,275	..	..	..	..	..	..	2,275	2,798	13	238	9	1,950	..	932	5,840	2,208	..	..	..	..	..	..	2,208
	December	1,895	..	..	..	..	..	..	1,895	8,375	13	238	0	1,950	..	932	6,623	1,840	..	..	..	..	..	..	1,840
	January .	..	..	..	..	..	..	..	..	8,375	13	238	0	1,950	..	932	6,623	..	..	..	..	..	..	..	..
	February	200	200	3,375	11	238	0	1,950	..	932	6,621	199	100
	March .	890	890	3,875	0	238	0	1,495	..	861	5,081	999	600

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Mr. G. C. LAURIE.

[Continue

URE I.

the past three years, 1914-15, 1915-16, and 1916-17.

. = 32,060 acres.
 = 16,030 acres.
 = 107 cusecs.

16							1016-17.													
RABI.							Kharif.							RABI.						
October.	November.	December.	January.	February.	March	TOTAL.	April	May.	June.	July.	August.	September.	TOTAL.	October	November.	December.	January.	February.	March.	TOTAL.
3,210	1,551	1,261	918	1,030	606	8,506	72	517	1,800	1,247	92	968	4,705	485	2,205	1,301	1,025	1,424	604	7,111
5,627	9,517	11,321	9,481	9,577	9,671	..	4,711	7,006	8,142	7,042	7,701	7,361	..	5,527	8,015	10,719	9,621	9,821	10,140	..
..	..	..	..	0 1	..	..	..	0 5	0 0	2 0	0 5	3 3	..	1 5	..	..	0 10	0 2	..	..

URE II.

on Bulana Distributary during the past three years, 1914-15, 1915-16, 1916-17.

1010,								1016-17.															
RABI.								Kharif.								RABI.							
Wheat.	Barley.	Mixed grain.	Sarson and Torta.	Gram.	Senji.	Miscellaneous.	TOTAL.	Sugarcane.	Rice.	Cotton.	Indigo.	Malze.	Juar.	Miscellaneous.	TOTAL.	Wheat.	Barley.	Mixed grain.	Sarson and Torta.	Gram.	Senji.	Miscellaneous.	TOTAL.
..	..	..	..	..	..	..	..	1,470	..	2,077	606	..	52	606	4,711	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,470	..	3,208	008	..	637	1,183	7,006	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,470	7	3,369	1,016	..	1,007	1,183	8,142	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,470	40	3,360	1,016	..	1,165	882	7,942	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,470	17	3,300	1,010	..	1,105	408	7,561	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,470	43	3,300	1,010	..	1,105	318	7,381	..	..	..	..	..	..	..	..
936	14	402	29	485	..	866	2,732	1,470	..	1,188	..	..	..	100	2,764	910	9	160	3	700	..	972	2,761
3,808	22	811	39	660	..	1,900	7,309	1,470	..	..	..	..	..	..	1,470	3,789	11	329	3	1,204	..	2,109	7,44
6,040	22	811	30	660	..	1,009	9,481	1,008	..	..	..	..	..	..	1,008	5,915	11	829	3	1,204	..	2,159	9,62
9,040	22	811	30	660	..	1,000	9,481	..	..	..	..	..	..	..	..	5,915	11	829	3	1,204	..	2,159	9,62
6,040	18	811	30	660	..	1,000	9,477	200	200	5,915	11	329	3	1,204	..	2,159	9,02
9,040	15	811	30	660	..	1,700	9,271	800	800	5,215	0	329	3	1,204	..	1,892	9,34

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Mr. G. C. LAURIE.

[Continued.]

ANNEX

Statement showing monthly flow of the Bixida Distributary, Karnal Division,

Culturable commanded area . . .
 Proposed annual irrigation . . .
 Authorized full supply . . .

	1914-15.														1915.						
	KHARIF.							RABI.							KHARIF.						
	April.	May.	June.	July.	August.	September.	TOTAL	October.	November.	December.	January.	February.	March.	TOTAL	April.	May.	June.	July.	August.	September.	TOTAL
Total of daily discharged.	1,187	1,044	1,716	830	805	1,500	7,901	1,122	1,030	1,560	752	..	1,141	6,520	1,437	1,226	2,015	1,955	2,514	1,000	11,047
Total irrigation as per subsidiary statement Annexure IV.)	1,500	3,375	4,104	5,165	5,425	5,700	..	3,443	3,136	7,555	6,882	7,093	8,317	..	1,660	1,002	2,570	3,649	4,505	5,164	..
Rainfall . . .	0.1	1.4	3.4	16.7	3.0	13.7	..	0.8	..	..	3.7	5.4	1.8	..	..	1.2	0.55	1.85	2.0	6.65	..

ANNEX

Subsidiary statement showing monthly area of principal crops irrigated on

Months,	1914-15.														1915								
	AREA IRRIGATED IN ACRES.														AREA IRRIGATED								
	KHARIF.							RABI.							KHARIF.								
	Sugarcane.	Rice.	Cotton.	Indigo.	Maize.	Juar.	Miscellaneous.	TOTAL.	Wheat.	Barley.	Gram.	Mixed grain.	Sarson.	Senji.	Miscellaneous.	TOTAL.	Sugarcane.	Rice.	Cotton.	Indigo.	Maize.	Juar.	Miscellaneous.	TOTAL.
April . . .	1,230	..	..	..	..	270	1,500	..	..	..	..	..	..	..	..	1,500	..	..	..	..	..	169	1,669
May . . .	2,208	18	401	..	36	7	620	3,375	..	..	..	..	..	..	..	1,715	12	3	3	..	4	255	1,092
June . . .	2,200	52	1,032	..	36	7	705	4,104	..	..	..	..	..	..	..	1,715	35	363	3	..	4	450	2,579
July . . .	2,211	762	1,340	..	86	13	804	5,165	..	..	..	..	..	..	..	1,715	250	704	3	7	12	895	3,649
August . . .	2,211	864	1,308	..	38	13	001	5,425	..	..	..	..	..	..	..	1,715	054	704	4	68	76	984	4,505
September . . .	2,211	1,014	1,422	..	86	18	040	5,700	..	..	..	..	..	..	..	1,715	1,032	810	4	200	0.5	1,050	5,464
October . . .	2,211	..	500	..	..	..	200	2,011	..	..	..	..	146	380	532	1,715	..	100	..	..	..	100	1,915
November . . .	1,908	..	..	..	..	..	..	1,008	308	..	..	..	222	038	1,228	1,438	..	..	..	..	..	..	1,438
December . . .	1,908	..	..	..	..	..	..	1,008	3,046	42	370	34	..	222	1,033	5,047	1,438	..	..	..	..	..	1,438
January . . .	..	..	..	..	..	..	..	..	5,054	42	376	34	..	222	1,154	6,882	..	..	..	..	..	..	..
February . . .	80	..	..	..	..	..	..	80	5,165	42	378	34	..	222	1,172	7,013	300	..	..	..	..	..	303
March . . .	040	..	..	..	..	..	..	040	5,474	42	378	48	..	222	1,210	1,377	1,200	..	..	..	..	..	1,233

Punjab]

Mr. G. C. LAURIE.

[Continued.]

URE III.

Western Jumma Canal for the past three years, 1914-15 to 1916-17.

Acres.

29,471 acres.

14,735 "

99 cusecs.

15							1916-17.													
RABI.							KHARIF.							RABI.						
October.	November.	December.	January.	February.	March.	TOTAL.	April.	May.	June.	July.	August.	September.	TOTAL.	October.	November.	December.	January.	February.	March.	TOTAL.
2,635	1,718	1,562	1,684	1,295	1,180	8,874	691	886	764	1,304	1,106	1,176	6,116	469	2,216	2,116	1,311	845	1,616	8,516
3,215	4,716	8,166	8,640	6,440	16,531	..	1,606	2,300	2,653	3,846	4,504	4,772	..	2,487	4,101	6,926	6,660	7,420	8,663	..
..	..	..	..	..	..	..	..	1-6	2-7	6-8	6-8	6-3	..	6-6	..	..	..	..	..	1-..

URE IV.

Razida Distributary during the past three years, 1914-15, 1915-16, 1916-17.

16.								1616-17.															
IN ACRES.								AREA IRRIGATED IN ACRES.															
RABI.								KHARIF.								RABI.							
Wheat.	Barley.	Gram.	Mixed grain.	Sarson.	Senji.	Miscellaneous.	TOTAL.	Sugarcane.	Rice.	Cotton.	Indigo.	Maize.	Juar.	Miscellaneous.	TOTAL.	Wheat.	Barley.	Gram.	Mixed grain.	Sarson.	Senji.	Miscellaneous.	TOTAL.
..	..	..	..	..	..	..	..	1,760	..	..	..	..	..	156	1,960	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,787	2	125	25	2	22	427	2,396	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,767	60	477	26	2	23	568	2,653	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,797	846	527	26	7	24	628	3,846	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,767	1,424	555	26	8	24	676	4,564	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	1,767	1,460	710	26	16	26	716	4,772	..	..	..	..	..	..	..	..
..	..	..	..	..	..	1,366	1,366	1,767	..	100	..	..	..	160	1,997	70	13	16	..	3	16	375	490
1,282	..	..	..	..	..	1,066	3,278	1,768	..	..	..	..	..	..	1,768	1,062	26	19	..	6	261	1,085	2,333
4,460	20	5	..	1	..	2,227	6,722	1,768	..	..	..	..	..	..	1,768	3,615	60	53	25	6	201	1,168	5,151
6,201	32	25	10	1	..	2,281	8,640	..	..	..	..	..	..	..	..	5,676	69	56	44	6	262	1,216	6,663
6,772	32	45	16	1	..	2,286	6,146	160	..	..	..	..	..	..	160	6,684	71	74	48	6	267	1,236	7,326
6,923	32	57	16	1	..	2,368	9,331	660	..	..	..	..	..	..	660	6,021	96	76	57	6	267	1,246	7,761

Punjab.]

Mr. G. C. LAURIE.

[Continued.]

Mr. G. C. LAURIE called and examined.

3230. (President.) We have been considering for a good number of years whether the supplies in the Jumna could not be increased. The Sarda Ganges scheme fell through because the United Provinces Government was not prepared to give the water. There was also another scheme for a dam on the Jumna which fell through because we could not get proper foundations. For a high dam it is very necessary to have a first class foundation and we could not get it. The project was investigated at great expense: a special subdivision was formed for it but the idea had to be given up. Now there are some schemes in connexion with the Sutlej which are somewhat complicated. The proposal is to construct a dam on the Sutlej so as to get extra supplies for the Jumna area. The principle is the same, though not exactly the same, as the triple project which has been recently carried out. It will take off the Sirsa branch from the Western Jumna Canal. The Sirsa branch is not the main cotton area. The Hansi branch is the main cotton area. As a matter of fact, during the last three or four years since the war started cotton has gone down tremendously on the Western Jumna Canal. One year there was an absolute failure of water. The supply was the lowest on record. The year before, when the war started, the zamindars were advised by the civil Department officials not to put cotton down. The area went down from 2½ lakhs to ¾ lakhs of acres. It was recovering this year. In 1914-15, the area was 222,330 acres, in 1915-1916, it was 105,221 acres, in 1916-17, it was 93,115 acres and in 1917-18, we had 1,50,000 acres but the crop was uncommonly poor on account of the excessive rainfall. I do not know what will happen next year. We have had three bad years. The first was owing to the price going down. The zamindars were advised not to put cotton down and they tried indigo instead. The next year there was very low supply in the river. This year there has been excessive rainfall. Prices are very high this year and so the people who got a poor outturn got a fairly good value for it otherwise there would have been a complete fiasco.

3231. (Mr. Ashton.) There is not the slightest chance of putting down earlier cotton, i.e., long staple cotton on the Western Jumna Canal. It would not be successful more than once in six years at the very outside on the present water supply. If we make the new dam on the Sutlej, we shall remove the Sirsa branch from the Western Jumna Canal but we shall also make equivalent extensions on the unirrigated areas. The two will balance: we shall not get any extra water. We are very short of water on the Western Jumna Canal at the time long staple cotton would be sown.

3232. The lining of canals depends absolutely on circumstances, such as the cost of material and the cost of the carriage. We could not line the main canal, because we could not get the closures as so much of the area under the canal has a very short rainfall and so we could not close the canals in order to line them. We have a very large percentage of places like Hissar, Rohtak, Jhind, Patiala, where the rainfall is practically nil in the cold weather. So we could not get canal closures during which the work could be carried out. That is one of the main troubles on the Western Jumna Canal.

3233. As to running a greater supply than the authorised maximum by strengthening weak places, our present trouble is to get a full supply to run. We have a very poor supply head to the canal at Dedupur where it crosses the Somb Nullah. The work was put in a hundred years ago and has been patched up to modern requirements. There are proposals to put an up-to-date level crossing there which will cost about twenty lakhs of rupees. The estimate has not yet been sanctioned by the Government of India but the scheme has been generally approved. We shall be better off then but the difficulty is, as I have stated in my written evidence, that we do not get our full supply which is 6,430 cusecs. When we do get it we do not want it. The Western Jumna Canal is so situated that if you can get water you generally do not want it, as it means that there has been a very heavy rainfall, and so people do not want canal water. The percentage of irrigation in the Western Jumna canal varies from branch to branch and from distributary to distributary. It was only recently laid down definitely and used to be rather haphazard. Our maximum is on two distributaries in Hissar where it is 75 per cent. but otherwise it varies from 33 to 50 per cent. An increase in the percentage would mean an increase in the discharge. We had to keep it down because we had not sufficient water. Over the greater part of the area, the percentage is 33 which is very low. To increase the percentage, you would have to enlarge the river as the Canal is meant to take what the river will give. July and August are the only months when we can depend on a full supply from the river and generally in those months we do not want it on account of the rainfall. Unless there is a flood, the river cannot as a rule give us more than 6,430 cusecs.

3234. Oil engines on wells and pumps on wells would certainly benefit the *rabi* crop but they would also help cotton by giving the cultivators a supply in February, March and April, before the canals are running their full supply. That, of course, is a general agricultural problem. It depends on the zamindars, and they do not as a rule consider it worth while to put down pumps. The water table is very low over the greater part of the Western Jumna Canal tract. It goes down to 150 feet in some parts. Over the greater portion of the tract it is very nearly 100 feet. In parts of the Karnal District water is available between twenty or thirty feet. The utilization of the sub-soil water is outside the scope of practical politics, owing to its depth.

3235. The average of the river supplies is very much increased by freshets. When there is a freshet in the river, the supply goes up to 12,000 cusecs so that a freshet once in six years raises the yearly average for that day by nearly 2,000 cusecs. Closures in May are practically non-existent. In 1912, the river supply could only give less than half the canal indent throughout February, March, April and May; the indent was never met until the beginning of July and the supply failed again from the middle of October. In 1914, the supply in the river was very short throughout February and March, and though the indent could generally be met during April and early May, there was no surplus in the river up to the 10th May. In 1915, owing to rainfall in February and March, the demand was low throughout and there was a surplus supply in the river; the indent was moderate in April and was usually met, though there was usually no surplus in the river during that month; the supply in the river rose in May and gave surplus water but failed again on 22nd October. In 1916, the river supply was exceedingly short throughout February, March, April and May. There have been no closures in May except on three occasions when we closed for five, seven and ten days respectively to carry out urgent work. We only close in May when there is absolute necessity. The difficulty is that we cannot get winter closures very often so we have to close for a few days in May when there has been rainfall and so the indent is very small. A point to be remembered in connexion with the diagram submitted with my written evidence is that we only get two-thirds of the supply in the river. The Eastern Jumna Canal has a right to the remaining one-third.

3236. (Mr. Roberts.) I was at Multan for five years, four of which were spent on the Sidhnai Canal and the other on the Lower Sutlej Inundation Canals. I constructed a large part of the Lower Jhelum Canal but

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Mr. E. R. Foy.

I left shortly after it started work. I was not there after the tract had been colonized but only in the initial stage of irrigation. I suppose cotton is safer in the western Punjab than in the eastern, i.e., on the Sirhind and Western Jumna Canal. This year was a year of excessive rainfall. That of course, you would not get in Multan but there you get more attacks by locusts. My experience of Multan District was some years ago. The damage due to locusts in Multan District was enormous in the old days. The main reason why cotton is not popular in the eastern Punjab is not untimely rainfall. I should say that insects do the worst damage. If there is short rainfall, there are insects and if there is excessive rainfall, the crop is damaged by it and the cotton is only well matured if you happen to get the intermediate state of affairs.

3237. I have not had any experience of American cotton. I see that ordinary *deshi* cotton on the Lower Chenab is sown early in April but on the Western Jumna Canal they sow *deshi* up to the end of June and the beginning of July. As regards the possibility of sowing American cotton in May on the Western Jumna Canal, as a rule, though not always, there would be sufficient water in May. Barring sugarcane, there is very little to compete against cotton in May. There is some scope for cotton sown in May if it is found free from insect pests.

3238. (Mr. Henderson.) As regards the danger of sub-soil water rising, over the greater part of the Western Jumna Canal tract we should only be too pleased if it did rise. There is only a small area which we are treating for damage and, except for that, I do not think there is any danger. It is very high in the neighbourhood of Delhi. We have reduced the water supply near Delhi for that reason. The depth depends on proximity to the canal. In some places in a well quite close to the canal, the depth is only ten feet while in one away from the canal it is thirty feet. Thirty feet is about the depth at which we should like it to be. I consider that fifteen feet is a dangerous level. It means that the water table is distinctly rising. "Shora" comes up to the surface and the soil becomes poorer. It is not absolutely dangerous until it rises to ten feet. Then the crops begin to give poor results. The danger area on Western Jumna Canal is, of course, only very local, but it is a matter of great importance to the people who own the particular plot of land. In Egypt, there is a very large drainage system. As a rule on the Punjab canals there is not a large area which is waterlogged. There used to be in former days. For instance, the original alignment of the Western Jumna Canal went through very much lower land and there is no doubt, if you read the reports of those days, that people were dying as a result of it all over the Karnal district. The Cantonment was moved from Karnal to Amballa because the former place had become absolutely insanitary. There was a very important Commission on the subject. The canal was reconstructed at great expense. Now it is sanitary. The population was dying out; there were very few children born. There is some very interesting correspondence on that subject which the Chief Commissioner of Delhi had reprinted recently.

3239. (President.) This was about 1870. In that case, owing to the seepage the whole spring level rose, and got very nearly up to ground level. The canal was an inundation canal and in those days had no masonry head so that the water could not be controlled properly.

3240. (Mr. Henderson.) On properly regulated perennial canals, the area affected by waterlogging is generally very small, and it is simply a local matter. It means a considerable loss to the owners of that particular tract but the tract affected is generally small.

3241. In April and May, want of labour is a great difficulty owing to all labour being employed in the wheat fields. Even if cotton were more valuable than wheat, I do not think it would take the place of wheat in the Punjab. There will always be a preference for wheat. The area under wheat over the whole of the Punjab including the irrigated and unirrigated tracts is six or eight times as much as that of cotton. I think six maunds rather too high an estimate of the average outturn of cotton. There was nothing like that this year.

3242. (President.) In regard to the remark in my written evidence that the enlarging of the canal would be detrimental to the wheat crop, which is the more important crop, and is likely to remain so, I would explain that if the canal were enlarged with the same amount of water running in the cold weather, we should have a broader canal with less depth and therefore we should have to head the water up so as to get it into the distributaries. If you head the water up, you lose a great deal of it and it interferes with the proper regulation of the canal. It is no use enlarging the canal unless you can also enlarge the water supply and that you cannot do on the Western Jumna Canal.

Mr. E. R. FOY, Superintending Engineer, Sirhind Canal Circle.

EXAMINED AT LAHORE, JANUARY 7TH, 1918.

Written statement.

VI.—IRRIGATION.

3243. (50) Experience.—I have twenty three years, of which ten years being on "construction" and on leave, thirteen years may be considered entirely devoted to irrigation work. I have experience of canal irrigation assessment work inasmuch as an irrigation officer of the Punjab has to fix values of crops in assessing *kharaba* (crops which fail to mature), and fixing classes of rates, to particular crops. My replies refer to the Sirhind Canal only; other officers will speak of other canals with which they are connected.

3244. (51) Wheat *versus* Cotton.—I am unhesitatingly of opinion that cultivators prefer wheat to cotton as an irrigated crop. The reasons are—

- (a) Wheat provides both grain and fodder for cattle.
- (b) Wheat can be sown on the *wadh* of maize of which there are large areas.
- (c) Sowing time for cotton comes when they are busy on harvesting large areas not only of canal wheat but also *barani* (unirrigated land); of the latter there are small areas on the dry tracts of colony canals.
- (d) Cotton requires more labour, and is more liable to diseases and total failure.
- (e) The soil on the Sirhind is generally light and sandy and the southern portion or three quarters of the irrigation tract is subject to heavy sandstorms, and young cotton in May and June is buried in scorching sand.

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Mr. E. R. Fox.

[Continued.]

3245. (52) (a) Critical periods in regard to water supply.—There are two critical periods—

- (i) In March and April—when no water is available in March till 10th April for cotton sowings all being needed for maturing *rabi*. After 10th April, there would generally be ample water for cotton sowings.
- (ii) In September and early October in a dry monsoon and low river, there might not be enough water in the river to mature large areas of cotton and also give *rabi* sowings. This might occur in about one year in four.

3246. (52) (b) Watering of cotton.—*Rauni* or first watering of four to five inches before sowing would be required in early April. But in the Ludhiana Division, they habitually sow late, even in June, so that it should not flower till the rains break, and so avoid the boll-worm.

Second watering three inches, twenty days or so after sowing.

Third and fourth waterings, each of three inches before flowering.

Fifth watering of three inches in September after flowering.

3247. (52) (c) Statistics.—Statistics are put up (Annexures I—IV.) They are very instructive and show—

- (i) The almost total cessation of cotton on British Branches following a good year. The cause was the panic caused by the war. The price of cotton at end of 1914 dropped to such a low figure (I think from Rs. 8 to Rs. 4 per maund) that people got frightened. In 1916, there was a marked improvement, and, in 1917, it rose again to 49,215, but unfortunately the heavy monsoon has damaged nearly all of it.
- (ii) More cotton on Native States Branches than on British Branches. The causes are said to be—
 - (a) Smaller holdings on Native States Branches inducing sowing of cotton as a valuable return on small areas. Fodder can be sown with it (such as *moth*) and *senji* can be sown on the *wadh* giving fodder and also as a fertilizer.
 - (b) Spring level is high in the upper reaches of the Native Branches and conditions are those of the Ludhiana District where cotton is grown. Ten miles below Barnala, the spring level is low and conditions are those of the Forezepore and Bhatinda Divisions, and little cotton is sown.
 - (c) It is also said water is not so carefully distributed on the distributaries of Native States Branches, and, when specially required, can be obtained as needed. This implies shortage on British Branches. I do not attach much weight to this as the time factor of the Sirhind in the *kharij* is about 0.48; that is canal runs full supply half time. There is thus ample water to run the channels more during the *kharij* if the demand were to increase owing to more cotton.

3248. (53) (a) Possibilities of expansion of area under cotton by enlarging canals.—On the Sirhind, the controlling factor is the *rabi* supply of the river. In the *kharij*, we do not utilize the available supply owing to lack of demand. Enlarging the channels of the Sirhind is quite unnecessary. In March in every year and in April most years there is insufficient water in the river.

3249. (53) (b) Effect of enlargement of canals in area under wheat.—On the Sirhind, increase of area of cotton would not affect the area under wheat, except in a year of bad monsoon and low rivers when September water would be required to mature cotton and could not be used for wheat sowings. In normal years with ample water for both, area of wheat would be unaffected as the percentage of annual irrigation to culturable commanded is very low, about forty per cent, and there is ample land available. On canals on which the incidence of annual irrigation to culturable commanded is high, land is not available and big cotton areas must reduce wheat areas.

3250. (54) Improvement in duty of water by remodelling of outlets.—We already aim at equal distribution from head to tail of a distributary, and no appreciable improvement seems to be possible. This adjustment or remodelling on a large scale was carried out a few years ago. I have no experience of modules.

(2) The effect of equalizing distribution on this canal would be simply to readjust areas.

3251. (55) Fluctuations in river supplies and their effects.—I refer to the rise and fall diagram for the year 1916-17 which I cannot submit with this note, as it is my record copy, but it will be found in the blue book of "Statistics of irrigation, water distribution and working of distributaries" of the Punjab canals for 1916-17 when it is published. We need only consider rise and fall up to and below the full supply requirements of the canal. Anything over 8,500 is surplus, and the canal cannot take it. On the diagram is plotted the average of the previous 31 years. From this it is clear that the river jumps up from the average early April supply of about 6,000 to 10,000 in less than a month. But it takes quite six weeks to drop from 10,000 to 6,000, possibly longer. The diagram is by gauges; discharges are to a very small scale and are not plotted, but discharges obtained by actual observations are noted on the diagram, and from these an approximate correlation can be arrived at.

(2) Bhakra gauges are kept by discharges, and five years' results, 1912-16, give an equal rise and fall, but the volumes available at the critical time in September are far more than in the critical time in April. In other words, in April the *zamindar* is dependent on the rise in the river, but in September he is unaffected by the fall, as there is always more than ample. These Bhakra results do not go far enough, as we have had two or three bad Aprils in succession and two or three good Octobers. This has equalized matters.

(3) *Zamindars* are held bound by custom and local usage. They know nothing about the rise and fall in the river, but are guided more in their sowings in April by the labour available in harvesting their *rabi* canal-irrigated cum-*barani* crop.

3252. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—In cases in which canals carry a supply for irrigation during the summer months only, it would be possible for the sowings and final waterings of cotton to be carried out by irrigation from wells where level is within thirty feet of N. S.

(2) In most part of Ludhiana District commanded by this canal, and in the Native States along the first thirty miles of Bhatinda Branch such a combination of irrigation from wells and canals would be feasible in the case of American cotton.

3253. (56) (b) Utilization of wells for irrigation of cotton in canal areas.—In Ludhiana District, wells are fairly numerous and are increasing, I believe. The steps possible are advice from canal and civil officers, and education of the people to the value of good cotton. Other measures are advances for sinking wells conditional on a certain area of cotton being sown, enhancement of water rate for *deshi* cotton and reduction for "American" cotton for a limited period of say five years till it catches on.

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Mr. E. R. Fox.

[Continued.]

3254. (56) (d) and (e) Construction of weirs *versus* construction of wells.—I do not think weirs should be built to "obviate" the use of wells. A weir to assure a supply of water in certain months is useful, but hand in hand with it should come an increase in the number of wells to assist in maturing the area increased on those canals which have been improved by their weir. Assuming a weir costs fifty lakhs, this would build 10,000 wells at Rs. 500 per well, but there would be neither labour nor cattle to work this number of wells, and such a proposal would be impracticable.

3255. (57) Effect of enlargement of canals on revenue.—I have already said this canal cannot be enlarged. No increase of revenue can be expected.

3256. (58) Cropping and causes affecting it.—Assume a holding of 100 acres, we aim at giving the cultivator annual irrigation to the extent of forty per cent. of culturable commanded. The *khari* to *rabi* proportion varies in the various divisions—

	Kharif.	Rabi.
Luddiana	2	3
Ferozepore	1	1.77
Bhatinda	1	2

The figures then become—

	LUDHIANA		FEROZEPORE.		BHATINDA.	
	Kharif	Rabi.	Kharif.	Rabi.	Kharif.	Rabi.
Sugarcane	0.2	...	0.1	...	Nil.	...
Maize	8.5	...	2.8	...	3.2	...
Cotton	0.6	...	0.3	...	1.6	...
Juar and <i>chari</i>	5.7	...	8.0	Including fodder.	6.8	<i>Chari</i> and <i>gowara</i> .
Miscellaneous	1.0	..	3.2	Including hemp, moth, melons	1.6	<i>Moth</i> and <i>chari</i> .
Wheat . . . . .	...	12.5	...	13.6	...	16.0
Barley . . . . .	...	3.2	...	4.0	...	4.0
Gram . . . . .	...	2.4	...	4.8	...	4.0
<i>Senji</i> and fodder . . . . .	...	3.9	...	1.9 0.3	...	2.8
Miscellaneous . . . . .	...	2.0	...	1.0	...	..
TOTAL	16	24	14.4	25.6	13.2	26.8
GRAND TOTAL	40		40		40	

(2) We aim at giving forty per cent. but in actual practice more is usually done. I do not think the proportions are affected by the water-supply, but by the nature of the soil and crops suitable for such soil. As already stated, there is ample land on the Sirhind for fodder crops and to preserve rotation without selecting special crops, sixty per cent. of culturable commanded can lie fallow annually.

(3) I do not think my proposals will alter areas appreciably. Wheat and barley will remain the same but perhaps, if cotton is grown more largely, *chari* and maize may fall off. It is impossible to make a forecast.

3257. (59) Practicability of lining canals.—I have no experience of the lining of canals. I have only been connected with experiments to produce cement slabs at a reasonable cost. It is not practicable to line a running canal unless there is a storage reservoir to draw on. Then by running canals full supply with water from the reservoir all crops can be given one good *kor* watering all round in the *rabi* followed by a closure of two months, then another watering to mature followed by another long closure. In this way, with long closures, lining work would be possible, otherwise not. New canals can be modelled initially and I unhesitatingly say this should be done when the extent of water saved makes it financially a remunerative undertaking.

3258. (61) Enlargement and lining of canals.—The enlargement of a canal could not be carried out in conjunction with lining. In connection with the Bhakra Dam Project we contemplated enlarging the feeder and lining it, but now find it will be preferable and economical to make an entirely new lined channel alongside and scrap the old.

3259. (62) Effect of lining of canals on seepage problems.—Given a canal running across the contours the effect would be extremely advantageous and even in all cases, though perhaps to a less extent. It is impossible to say to what extent expenditure would be justified; so much depends on conditions of soil, value of land liable to be waterlogged, height of water-table and conditions of outfall drainages.

3260. (63) Effect of lining of canals on supplies.—Generally speaking, the effect of lining on supplies would be immaterial in the summer months as there is generally ample water in the Punjab rivers. In the winter months, it would improve the supply by saving absorption losses according to the efficacy of lining material selected. It may be assumed that 75 per cent. of such losses will be saved. It will probably be more, but this percentage is safe. Whether it can be justified is a matter of calculation to see if saving of water so effected will give enough additional irrigation to produce a revenue adequately proportional to the cost of the lining.

Punjab.]

Mr. E. R. Foy.

[Continued.]

ANNEXURE I.

Statement showing indent and supply of canal and river during 1914, 1915 and 1916, of the months noted below, that is for the "critical periods."

Months.	1914.			1915.			1916.		
	Indent.	Supply in canal.	Supply in river.	Indent.	Supply in canal.	Supply in river.	Indent.	Supply in canal.	Supply in river.
March . . .	8,816	128,560 4,147	Insufficient .	5,960	143,038 4,768	Insufficient .	8,344	115,522 3,727	Insufficient.
April . . .	5,933	140,557 4,685	Insufficient .	5,194	106,956 5,093	Sufficient .	7,416	140,166 5,101	Insufficient.
September . .	4,650	110,845 5,542	Surplus .	7,777	218,928 7,293	Sufficient .	5,869	156,132 5,782	Sufficient.
October . . .	4,448	140,650 4,537	Surplus .	7,781	227,554 7,340	Surplus till the end of the month.	7,600	236,601 7,632	Sufficient.

ANNEXURES II-IV.

Punjab.]

Mr. E R. Fox.

[Continued.]

ANNEX

Statement showing average monthly area of each

Name of Crop.	OCTOBER.					NOVEMBER.					DECEMBER.				
	1914-15.	1915-16.	1916-17.	TOTAL	Average	1914-15.	1915-16.	1916-17.	TOTAL	Average	1914-15.	1915-16.	1916-17.	TOTAL	Average
<i>British.</i>															
Wheat	2,751	3,385	8,939	15,075	5,025	40,844	76,026	94,166	211,036	70,345	95,102	139,323	68,862	303,347	101,116
Barley	257	6,112	2,734	9,103	3,034	7,757	47,254	30,715	85,726	28,575	18,929	61,094	25,149	109,071	36,357
Mixed grain	5	7	29	41	14	513	400	727	1,640	547	627	1,840	167	2,640	880
Sarson	47	642	324	1,013	338	400	907	995	2,398	790	2,085	1,395	1,460	4,940	1,650
Gram	2,703	8,592	13,726	25,021	8,340	31,774	33,174	55,070	123,018	41,006	65,188	86,330	50,002	202,180	67,493
Senji	2,632	1,045	2,704	6,381	2,127	6,322	9,015	10,491	25,828	8,610	6,975	11,308	0,202	24,575	8,102
Miscellaneous	43,200	132,275	140,805	325,430	108,477	64,124	89,030	22,991	176,154	58,718	-24,067	-121,376	-32,654	-17,890	-59,600
Sugarcane . . . . .	..	..	..	..	..	..	..	..	..	..	-23	-5	3	-25	-8
TOTAL	51,085	152,058	178,321	332,004	127,355	154,830	255,812	216,163	623,800	208,600	103,075	183,005	120,100	468,040	156,014
<i>Native States.</i>															
Wheat	23	713	89	825	275	11,423	15,149	21,518	48,090	10,030	50,454	61,406	72,796	184,056	61,552
Barley	8	524	274	806	269	1,046	7,409	4,496	13,041	4,347	11,134	28,984	27,892	108,010	22,070
Mixed grain . . . . .	..	197	2	199	66	269	2,501	1,058	3,888	1,290	0,541	7,719	9,274	23,534	7,845
Sarson	1	5	..	6	2	254	298	240	792	264	2,835	2,655	2,508	8,058	2,086
Gram	42	203	13	318	100	3,043	4,100	4,720	12,469	4,150	14,650	14,505	20,992	50,153	10,718
Senji . . . . .	..	..	58	58	19	2,124	1,109	2,284	5,517	1,839	10,578	9,008	13,100	32	10,015
Miscellaneous	1,907	0,002	3,628	11,537	3,846	27,700	50,184	37,095	121,579	40,520	13,378	70,000	40,076	168,520	6,173
Sugarcane . . . . .	..	..	..	..	..	..	..	..	..	..	-007	100	135	-420	-142
TOTAL	1,981	7,704	4,004	13,749	4,583	46,459	86,900	72,017	205,370	68,458	138,909	203,509	192,833	535,251	178,417
GRAND TOTAL	53,066	159,762	182,325	395,813	131,938	201,289	342,712	287,175	831,176	277,058	302,884	387,414	312,933	1,003,291	334,431

These are prepared from monthly statements giving only approximate

Punjab.]

Mr. E. R. Fox.

[Continued.]

URE II.

crop irrigated during Rabi, 1914-15, 1915-16, and 1916-17.

JANUARY.					FEBRUARY.					MARCH.					Half-yearly total.	Half yearly average.
1914-15.	1915-16	1916-17.	TOTAL.	Average	1914-15.	1915-16	1916-17	TOTAL	Average	1914-15.	1915-16	1916-17.	TOTAL	Average.		
40,471	47,283	61,713	155,472	51,824	6,310	4,131	6,830	17,274	5,758	8,378	3,318	20,780	32,482	10,827	734,096	244,895
11,788	5,710	15,948	33,455	11,152	014	1,187	1,895	3,996	1,332	1,066	594	13,610	15,276	5,092	256,627	85,542
1,502	192	—300	1,334	445	22	46	102	170	57	152	31	40	232	77	6,057	2,020
1,302	421	630	2,403	801	72	34	102	208	69	80	0	620	686	229	11,657	3,886
36,031	6,043	18,552	60,626	20,208	2,354	3,524	2,169	8,347	2,782	2,555	1,164	2,236	6,065	2,002	425,497	141,831
2,905	1,503	316	4,781	1,593	101	48	46	195	65	31	7	81	146	47	61,008	20,036
—44,010	—40,527	—75,623	—160,160	—53,387	1,421	78	10	1,509	503	1,116	—408	—26,607	—25,960	—8,653	137,076	45,992
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	—25	—8
56,049	20,639	21,220	97,914	32,638	11,104	0,051	11,454	31,600	10,560	13,357	4,720	10,784	28,801	9,021	1,084,378	544,704
39,104	39,635	27,432	106,231	35,410	4,108	7,853	4,005	16,656	5,552	3,385	8,720	5,054	17,169	5,720	1,378,617	124,530
11,053	22,302	11,201	44,556	14,852	2,056	3,075	2,182	7,313	2,438	671	6,727	2,124	0,522	3,174	143,248	47,750
4,310	6,393	2,370	13,084	4,361	519	101	—675	—52	—17	263	690	367	1,350	450	42,093	14,001
1,005	1,641	1,164	4,740	1,580	—50	—81	527	396	132	461	364	3	858	286	14,350	4,950
0,006	12,802	6,941	28,249	9,416	1,002	2,340	1,584	5,520	1,842	751	1,441	1,473	3,065	1,222	100,380	33,400
4,410	6,405	5,370	16,245	5,415	285	2,964	310	3,559	1,186	504	1,414	570	2,578	850	66,708	20,233
—9,073	—36,430	—16,101	—62,594	—20,864	—2,752	—8,748	—1,476	—12,070	—4,325	—2,226	—15,371	—6,210	—23,807	—7,936	202,250	67,420
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	—420	—142
50,881	52,313	38,317	150,511	50,170	5,768	7,507	7,147	20,422	6,803	3,959	3,985	3,881	11,325	3,775	936,634	312,211
115,930	72,032	59,543	248,425	82,808	16,962	16,358	18,001	52,121	17,374	17,316	8,705	14,165	40,186	13,396	2,371,012	857,005

figures month by month for the Irrigation Operation Statement.

Punjab.]

Mr. E. R. Foy.

[Continued.]

ANNEX

Statement showing average monthly area of each crop irrigated

Name of Crop.	APRIL.					MAY.					JUNE.				
	1914.	1915.	1916.	TOTAL	Average	1914.	1915.	1916.	TOTAL	Average	1914.	1915.	1916.	TOTAL	Average
<i>British.</i>															
Sugarcane	144	350	1,200	1,694	595	320	511	385	1,216	405	258	81	20	300	123
Rice . . . . .	..	..	..	..	..	..	..	..	..	..	5	..	..	5	2
Cotton	1,048	144	1,284	3,079	1,025	8,019	298	2,051	10,065	3,055	5,342	429	1,823	7,601	2,536
Indigo . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Malze . . . . .	..	..	1	1	..	2	3	21	20	9	59	34	28	112	37
Juar and Charl	1,094	97	5,078	6,269	2,089	10,778	293	20,472	31,453	10,484	30,037	924	35,959	72,007	24,223
Miscellaneous	11,083	2,758	25,030	38,860	12,950	28,512	3,113	20,972	51,597	20,533	44,004	2,841	47,040	94,491	31,497
TOTAL	15,990	3,340	32,692	49,920	16,640	47,028	4,128	63,501	105,257	35,086	86,350	4,306	84,673	176,235	58,412
<i>Native States.</i>															
Sugarcane	181	407	798	1,356	452	1,142	1,405	1,752	4,389	1,463	420	388	1,108	1,911	637
Rice . . . . .	..	..	..	..	..	..	..	..	..	..	05	272	113	480	160
Cotton	3	22	2	27	9	2,221	21	448	2,690	897	13,175	1,760	10,770	25,795	8,558
Indigo . . . . .	..	..	13	13	4	40	..	80	120	43	..	74	805	879	120
Malze . . . . .	..	..	1	1	..	60	1	7	68	23	224	27	147	308	133
Juar and Charl	210	2	32	253	84	4,161	76	3,873	8,100	2,790	11,138	474	10,650	28,262	9,421
Miscellaneous	847	883	1,513	3,243	1,081	12,814	2,545	11,976	26,534	8,844	20,040	5,013	34,081	60,043	20,014
TOTAL	1,250	1,314	2,320	4,893	1,631	19,028	4,138	17,844	41,010	13,970	49,001	8,008	93,160	117,178	39,059
GRAND TOTAL	15,219	4,653	34,931	54,813	18,271	67,050	8,266	71,345	147,107	49,050	132,357	12,3142	1147,742	292,413	97,471

These are prepared from monthly statements giving approximate

ANNEX

Statement showing average monthly discharge of the

Name of Branches	Full supply.	APRIL.					MAY.					JUNE.				
		1914.	1915.	1916.	TOTAL	Average	1914.	1915.	1916.	TOTAL	Average	1914.	1915.	1916.	TOTAL	Average
Combined Branch	5,401	2,638	2,452	3,254	7,744	2,581	3,764	1,792	3,487	9,043	3,014	3,345	1,293	4,070	8,714	2,906
I Feeder Mle III	3,086	2,211	2,128	1,457	5,796	1,932	2,360	1,780	2,196	6,286	2,095	2,241	1,017	3,072	6,980	2,310
TOTAL . . . . .	..	4,249	4,580	4,711	13,540	4,513	6,073	3,572	5,683	15,328	5,109	5,586	2,310	7,148	15,694	5,215

Statement showing average monthly discharge of the

Name of Branches	Full supply.	OCTOBER.					NOVEMBER.					DECEMBER.				
		1914-15.	1915-16.	1916-17.	TOTAL	Average	1914-15.	1915-16.	1916-17.	TOTAL	Average	1914-16.	1915-16.	1916-17.	TOTAL	Average
Combined Branch	5,401	2,466	3,931	4,305	10,702	3,567	3,392	3,445	3,594	10,431	3,477	2,797	2,428	2,769	7,994	2,935
I Feeder Mle III	3,086	1,832	3,013	2,657	7,502	2,501	2,366	2,266	2,367	6,999	2,293	2,189	1,873	1,933	5,986	1,996
TOTAL . . . . .	..	4,298	6,944	6,962	18,204	6,068	5,758	5,711	5,961	17,430	5,770	4,987	4,301	4,702	13,980	4,536

Punjab.]

Mr. E. R. Foy.

[Continued.]

URE III.

during Kharif, 1914, 1915 and 1916.

JULY.					AUGUST.					SEPTEMBER.					Half yearly total.	Half yearly average.
1914.	1915.	1916.	TOTAL.	Average	1914.	1915.	1916.	TOTAL.	Average	1914.	1915.	1916.	TOTAL.	Average		
16	19	14	40	13	19	31	4	45	15	75	1	1	77	26	3,441	1,147
..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	5	2
1,763	335	1,029	3,667	1,622	349	201	9,526	7,673	2,358	676	21	31	728	243	32,506	16,833
..
4,740	392	4,261	9,315	3,165	14,628	48,639	23,030	87,296	29,068	18,855	6,976	15,999	41,839	13,943	138,490	46,163
49,082	18,565	75,251	140,798	46,933	26,281	80,557	32,766	148,544	49,515	9,149	32,394	6,665	47,518	15,839	447,240	149,081
50,189	49,691	21,028	120,308	40,103	1,983	37,363	-34,253	4,103	1,398	6,113	-11,95	8,361	-7,957	-2,652	311,512	103,838
163,633	68,809	161,586	273,528	91,176	42,348	175,701	28,922	247,661	32,344	24,868	28,249	10,670	82,199	27,300	1,033,197	311,067
339	129	188	653	218	124	9	16	149	50	689	11	..	607	236	9,165	3,950
235	526	1,274	2,985	695	1,429	1,146	1,782	4,354	1,451	682	852	450	1,984	691	8,093	2,062
19,044	7,825	9,785	34,254	11,418	2,663	3,864	2,442	8,460	2,823	2,680	596	898	3,454	1,152	74,599	24,897
..	1	97	98	33	..	1	19	20	7	..	2	2	4	1	943	217
1,399	379	870	2,555	852	7,558	17,884	10,027	36,369	12,123	9,259	9,062	7,491	26,822	8,874	69,013	22,004
19,612	3,968	31,430	54,439	18,146	17,170	40,975	18,941	77,095	25,698	10,345	30,894	5,953	47,192	15,731	215,341	71,786
16,377	26,685	22,535	95,597	21,865	-739	33,544	-7,672	25,733	8,578	-806	-2,704	5,799	-9,399	-3,139	171,766	57,252
53,954	39,533	90,194	150,681	53,227	28,211	96,923	27,655	152,189	59,736	22,159	39,583	8,824	79,563	23,521	549,411	182,137
157,587	107,842	167,789	433,299	144,493	76,550	272,714	55,977	399,250	133,084	57,924	67,832	27,063	152,759	50,926	1,479,611	493,204

figures month by month for the Irrigation Operation Statement.

URE IV.

following Branches during Kharif, 1914, 1915 and 1916.

JULY.					AUGUST.					SEPTEMBER.					TOTAL.	Average.
1914.	1915.	1916.	TOTAL.	Average.	1914.	1915.	1916.	TOTAL.	Average.	1914.	1915.	1916.	TOTAL.	Average.		
2,215	2,514	4,904	8,793	2,031	2,191	3,813	1,835	7,842	2,014	3,293	4,469	2,740	10,511	3,504		
1,467	1,941	3,142	6,490	2,163	1,676	2,422	2,164	6,196	2,065	1,964	2,424	2,392	6,766	2,256		
3,622	4,455	7,266	15,233	5,604	3,804	6,235	3,939	14,938	4,679	5,257	6,893	5,141	17,271	5,757		

following Branches during Rabi, 1914-15, 1915-16 and 1916-17.

JANUARY.					FEBRUARY.					MARCH.					TOTAL.	Average.
1914-15.	1915-16.	1916-17.	TOTAL.	Average.	1914-15.	1915-16.	1916-17.	TOTAL.	Average.	1914-15.	1915-16.	1916-17.	TOTAL.	Average.		
2,920	1,033	2,215	6,777	2,259	1,618	2,104	2,316	5,522	1,841	2,744	2,139	2,042	6,925	2,308		
1,539	1,585	1,424	4,548	1,516	1,831	1,296	936	3,663	1,221	1,749	1,243	1,183	4,186	1,393		
4,198	3,518	3,639	11,325	3,775	2,899	3,490	3,296	9,185	3,062	4,493	3,382	3,230	11,105	3,701		

Punjab.]

Mr. E. R. Fox.

[Continued.]

Mr. E. R. Fox called and examined.

3261. (Mr. Ashton.) The Sirhind Canal takes off from the Sutlej at Rupar and runs on the left bank of the Sutlej river. One branch belongs to three Natives State who paid for it themselves. We have had two very bad seasons on the Sirhind Canal. After the 10th of April, there is not very much demand for *rabi*. From the 1st April, the demand begins to fall off. Unfortunately, 1916 and 1917 were very bad years: the river did not rise till May and June as the winter in both years was dry and there was no snow on the hills. Usually there would be ample water after the 10th of April for cotton sowings. There would not ordinarily be any shortage of water in September or October. That would happen very seldom. Our permissible percentage of irrigation to culturable commanded is rather low. It was as low as 33 but we have worked it up to forty. The canal was designed for less than that originally but at the last remodelling we made it forty.

3262. There are several factors that come in with regard to the demand for water in *kharij*. There are very large *barani* areas in the tract commanded by this canal which have to be harvested. If there is a very big *rabi* crop, there is no labour available for early *kharij* cultivation. People cannot be bothered to take water. In 1914-15, the *rabi* crop, especially on the *barani* lands was very heavy and the result was that up to the end of June there was only 25,000 acres of *kharij* irrigation on the Sirhind Canal. The monsoon failed that year and, eventually, the *kharij* cultivation was the second best on record in spite of the bad start. One cannot say exactly what is going to happen on our canals in the *kharij* months. If there has been a very good *kharij*, they start with a poor *rabi*. There is no chance of their dropping *rabi* for *kharij*.

3263. As a matter of fact before the Committee was appointed, I had taken up the question of growing cotton on the Sirhind Canal. In 1914, the cotton sowings were fairly good but then, owing to the drop in prices of cotton due to the war, nobody sowed cotton at all. The sowings in 1915 were very poor—only 1,525 acres. This year, there was a big jump but the crop was spoilt by the monsoon.

3264. There is very little land irrigated by wells in the lower half of the tract as the spring level is very low. In the upper reaches spring level is high. The remainder of the culturable area is under *barani* conditions. It is the case that the people do not use the supply of water that is available in *kharij*. They could increase the area under cotton if the variety grown were one that did not want very early watering, say, before the 10th April or watering after the first week in October.

3265. If the canals were waterproof lined, the *rabi* crop would be advantageously affected. Waterproof lining is not required for the *kharij* because there is then ample water but in the *rabi* we have not got it. Lined channels would give extra water in March and early April when water is not ordinarily available for sowing cotton.

3266. Irrigation by wells for helping the canals is impracticable on a large scale. I have very little information about wells but, if well irrigation is to be done on a very large scale, cattle would be required and I do not think that the stock is there. The upper region of the canal is very badly waterlogged. It is ideal for wells and pumps in place of canal irrigation. There is ample power available: as there are many falls. The question of conversion of perennial into only *kharij* channels was taken up some years back, about 1902 or 1903, and five or six of the distributaries were made purely *kharij* channels. I am taking it up again. I want to convert several more into *kharij* channels but the trouble is the Native States; it is difficult to get them to agree. The Darbars do not look at it in the same way that we do. The upper reaches of the canal, especially the Native States branch, are so waterlogged that water is coming out this year at the top of the wells. Over a very large part of this tract it is within five feet of the surface. The power is there and, so far as the British territory is concerned, pumps could be introduced as soon as the plant becomes available. American cotton could be grown on the upper reaches of the canal if pumping plants were first put down. If the plants were worked from the canals, their working would synchronise with that of the canals. Of course, they could be worked otherwise than by power from the canals. If worked from the canals, they would be no better or worse off than the canals. I should think that at least a quarter of the gross area commanded by the canal system could be irrigated from wells and pumps. Three quarters would still require canal water. As to the locality of the area, it is roughly a strip thirty miles wide below the railway line from Auhalla to Ludhiana. Pumps could be installed anywhere in the tract between the railway line and a line right across thirty miles below it. The water is quite close to the surface from five to twenty feet. Then it suddenly drops to 100 feet below the surface. Pumping would make canal water available elsewhere. It would tend to increase the incidence in other parts. Instead of forty per cent, sixty to seventy per cent. of the gross culturable area could be irrigated.

3267. (Mr. Roberts.) Cotton requires more labour than wheat in the sense that it requires more actual cultivation in the way of weeding and so on. The weeding would not clash with wheat as it would come in June and July. With regard to sowing American cotton in these tracts, it could not be sown in March but could be sown after the 10th of April as water would then be available. It could be sown on the upper reaches but on the lower reaches, on the borders of Bikaur desert, the young plants would get scorched by dust-storms in May and June. In the lower part of Ferozepur and on the Bhatinda branch, it would be necessary to sow late in order to get the plants protected by the monsoon. The soil is, however, very sandy and I do not think it is suitable for cotton. It is very good for gram and is more suitable for *rabi*.

3268. I have no experience of American cotton. If the price of cotton is assured, I think the *zamindar* has enough business acumen to sow a crop that will pay him well. If cotton pays him, he will grow it. I tried to get cultivators to sow American cotton this year and the Executive Engineers took a lot of trouble over it. We got American seed from Montgomery and sold it to the cultivators but unfortunately the crop was a total failure. It was sown in Ludhiana and part of Ferozepore but heavy rain at the end of October killed it off and we had rather a set back. The outturn was worse than that of *deshi* cotton. In the beginning of October it was reported on rather favourably but the very heavy rain at the end of October, six to eleven inches, killed it off completely. The rainfall was absolutely abnormal, and I do not think that rain after the first week of October has ever been known in that tract. It is impossible to base any general observations on this year's experience.

3269. I do not think September will be a critical time for cotton. October perhaps will be but I do not think that we shall ever be short of water in September. Even when the summer river was the lowest on record in 1916, there was a discharge of 50,000 cusecs and it did not fall below canal requirements till the end of October.

Punjab.]

Mr. H. W. M. Ives.

3270. I do not think that pumping would involve much danger of the sub-soil level being brought too low because there is a very high water table right back to the Sivaliks. In fact it is so high that we draw water from the water table into the Sirhind Canal by pipes. The water table is so high that I do not think that any pumping would adversely affect it.

3271. (*Mr. Henderson.*) The intensity is as low as forty per cent. for the reason that the Sirhind is one of the early canals; the idea was to spread the water over as large an area as possible. At the beginning, the intensity was only twenty per cent. The land is not held by big *zamindars* except perhaps in parts of the Ferozpur district. There are large individual holdings in the Mukteswar Tehsil. The holdings elsewhere on the Sirhind are all peasant holdings held by cultivators. I do not think it would make any material difference now if the land were divided up into squares. It is too late for that. It means an entire re-organization of the water course system. There is a very large area of pure *barani* cultivation.

3272. As to the prospects of the increase of the area under cotton in Rajputana, an officer is now on special duty in the circle to get out a big project to take water into Bikanir. That would open up an enormous area. I do not know the nature of the soil but I should say that it would be good soil for the cultivation of cotton, better than that higher up. The sand question would right itself after years of cultivation. Probably if the Sutlej Valley Canals were improved, the blowing of sand would be stopped to a large extent.

3273. I do not think that the canals are badly aligned but perhaps some of the distributaries are. Water-logging must be mostly due to seepage from the canal.

3274. The proportion of cultivation is gradually increasing and I think it has about reached its limit now owing to the water being available. The river supply is limited. The winter supply in the river is the limiting factor. There is no demand among the cultivators for more intensive cultivation. They are doing, I suppose, more than their fathers and I believe they are more or less content. It is not a colony and you could not colonise.

3275. (*President.*) I am quite in favour of the utilization of sub-soil water by pumping and a system of distribution by electric power. The chief obstacle to the lining of canals is, of course, that it would necessitate the closure of the canals to execute the work. Another obstacle is the lack of a cheap supply of cement. I think we can line a new canal and that it would be worth our while to do so in the first instance. In fact, in the project for the new canal into Bikanir which is under preparation, we propose to line the main canal and the branches. That will be a real and practical experimental test. We find by calculation that we can afford to spend Rs. 40 per hundred square feet for lining. Taking the reduced size of the channel required less land, smaller bridges and the capitalized value of the water saved into consideration, Rs. 40 would be a safe figure. It is costing us that to do lining in small patches.

3276. It will be difficult to wear down the preference for wheat against cotton.

3277. (*Mr. Wadia.*) The water rates for cotton in the two zones in the Sirhind Circle are Rs. 4 and Rs. 3-12. If the rates were lower, I do not think that the people would grow more cotton. It is so very low now that I do not think a reduction would make any material difference.

3278. (*Mr. Henderson.*) In a year like this, practically the whole area under the canal is cultivated except, of course, roads and village sites. Scarcely a field was not sown. Almost every bit of it was sown *barani* and we had practically no irrigation at all, i.e., at the beginning of the *rabi*, but by the end of the crop we had picked up about 500,000 acres, the lowest on record for very many years and about half of the preceding year's *rabi* crop. The *barani* crops are maize, wheat, grain and barley in *rabi* and in *kharif*, *juar* and maize. There is no *barani* cotton, as far as I know on the canal tract but adjacent to it there is, I think, in the strip mentioned in paragraph 3266 above north of the Native State Feeders and in the Maler Kotla State between the Bhatinda and Kotla Branches. But this *barani* cotton is, I think, also protected by walls.

Mr. H. W. M. IVES, Superintending Engineer, Upper Jhelum Canal Circle.

EXAMINED AT LAHORE, JANUARY 7TH, 1918.

Written statement.

I.—AGRICULTURAL EXPERIENCE.

(a) *Deshi short staple cotton.*

3279. (1) Experience.—The last Revenue Division I had charge of was on the Lower Jhelum Canal at Sargodha (District Shahpur) from February 1903 to October 1905. Irrigation on this canal was, however, only in its infancy then and had not been fully developed. The next connexion I had with Revenue was as a Circle Officer, on the Upper Chenab Canal from January 1914 to March 1916. This charge embraced canal irrigated parts of the Sialkot, Gujranwala, Lahore, Lyallpur and Montgomery Districts. But here too irrigation was at the time in its infancy, and as a Circle Officer, I had not the same opportunities of being in touch with cultivators as officers in charge of Divisions have. Lastly, I have been in charge of the Upper Jhelum Canal as a Circle Officer since April 1916, which charge embraces canal irrigated tracts of the Gujrat District principally, with very small areas of Kashmir Territory and of Shahpur District, but on this canal too, irrigation having only started from the *kharif* of 1916, it is not anywhere near fully developed yet.

3280. (2) Varieties.—In the Gujrat District, only one species of *deshi* cotton is grown, viz., the ordinary short staple inferior quality of the Punjab.

3281. (3) Size of holdings.—Holdings are generally very small and according to the Settlement Report, the average cultivated area per share holder is:—

	Acres.
Gujrat Tahsil	5
Kharian	5
Phalia	7

(2) The total canal irrigated area during *kharif* 1917 on the Upper Jhelum Canal was 70,592 acres of which 23,340 acres were cotton (principally *deshi*) or 31 per cent. of the *kharif* irrigated area.

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[Continued.]

3282. (4) Yields and profits.—The average yield per acre is six to seven maunds and taking an average rate of Rs. 5 per maund the sale proceeds per acre would be Rs. 32. The cost to the cultivator is about Rs. 24; therefore the average profit per acre is about Rs. 8. These are, however, rough approximations.

3283. (5) Rotations and manures.—Cotton being a long term crop, does not admit of much rotation with other crops but various crops, such as *moth*, *makki*, *juar* and melons are sown mixed with it, and *senji* is occasionally sown in it, after the picking season is over. Generally no manure is used, but in rare cases, when it is used, it consists of the ordinary village manure.

3284. (7) Conditions affecting increase in area.—No appreciable fluctuation has been experienced so far. As canal irrigation develops on this canal, doubtless the area under cotton will also develop.

3285. (8) Uses of seed and seed selection.—The seed is used for sowing and as food for cattle. Seed selection is in vogue. Good cotton is separated from the rest and the seed of this is used for sowing. All such seed is hand-ginned in the ordinary country hand gin, called the *belna*.

(c) Exotic cotton.

3286. (21) Varieties.—American cotton is just beginning to be introduced on this canal. Out of the total area of 23,340 acres of cotton referred to in paragraph 3281 above 3,181 acres were of the American variety.

3287. (25) Conditions affecting increase in area.—The cotton area has increased since the introduction of canal irrigation. In the pre-canal days according to the Settlement Report, the percentage of cotton sown in the Gujrat District was only two generally.

V.—GENERAL.

3288. (47) Effect of water rates.—The water-rate charged seems to have no effect so far, on the cultivator's preference for a particular crop. He appears to be guided entirely by his own requirements.

3289. (49) Effect of tenure of land.—The tenure of land on the Upper Jhelum Canal has no bearing on this question, as the holdings are generally small.

VI.—IRRIGATION.

3290. (50) Experience.—My experience is limited to irrigation under canals, and is as below:—

As a Sub-Divisional Officer on the Sirhind Canal (1890 to 1892). As a Sub-Divisional Officer on the Lower Chenab Canal (1896 to 1897). As a Divisional Officer on the same from 1898 to 1901. Lastly, also that given in paragraph 3279 above. The remainder or bulk of my service (begun in April 1889) has been on the construction of new canals in the Province (Punjab). As a Divisional Canal Officer, I have had experience of canal irrigation assessment work.

3291. (51) Wheat *versus* cotton.—Cultivators prefer wheat to cotton generally. In pre-canal days in the Gujrat District, 39 per cent. of the area sown was wheat, compared with two per cent. of cotton.

The reasons for this preference are:—

(i) Wheat is a more certain crop than cotton because:—

(a) it is on the ground for a shorter period;

(b) requires smaller delta of water;

(c) is less liable to failure on account of disease, blight, etc., than cotton.

(ii) Wheat is a food crop.

(iii) The average profit per acre is more than or equal to, but rarely less than that for cotton.

(iv) Harvesting of wheat is less laborious, less costly and is spread over a shorter period.

The question of export of either of the two commodities does not at present arise on the Upper Jhelum Canal as both are so far practically entirely consumed locally.

3292. (52) (a) and (56) Critical period in regard to water supply and the utilization of wells for irrigation of cotton in canal areas.—Questions 52 (a), 56 (a) and 56 (b) can be answered together. The critical period on canals in the Punjab generally is from 15th September to 15th October, when the river supplies begin to fall and there is simultaneous demand for maturing *kharij* (especially rice) and sowing *rabi*. If working wells exist in any tract in sufficiently large numbers, there is a possibility of tiding over this difficulty. In the case of *deski* cotton, there is always sufficient water in the canals, during its sowing period, and at time of maturing it requires only the last watering by 15th October. In ordinary years, the rivers are not very low during the critical period mentioned above and there is always a possibility of partial help from a canal for the last watering for cotton; in bad years, a last watering can be given entirely from wells, which are fairly plentiful on the Upper Jhelum Canal. Thus, if there be no other inducement to the cultivator for growing cotton, the question of canal supplies will not stand in his way on the *kharij* distributaries of the Upper Jhelum Canal. On perennial distributaries, where wells are being abandoned the same amount of help perhaps cannot be relied on.

3293. (52) (b) Watering of cotton.—*Deski* cotton requires seven waterings as a maximum as follows:—

First watering for sowing in April. Second watering at end of May. Third and fourth between the end of May and middle of July. This means about four waterings before the monsoon period. The fifth watering is required between the middle of July and the middle of August. The sixth between the middle of August and the middle of September. If rains are good, the fifth and sixth waterings with canal water are not needed. The seventh and last watering is required about middle of October. Each watering is about three inches in depth, which means about 10,000 cubic feet per watering per acre.

3294. (52) (c) Statistics.—Irrigation began on the Upper Jhelum Canal from the *kharij* of 1916 only and then only in a small way and is far from developed still since all the distributaries have not been fully constructed yet. Any data supplied about them will thus be of no practical value, while the canal has been running for too short a time to permit of supply of figures of averages even for the past three years.

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Mr. H. W. M. Ives.

[Continued.]

(2) Since we do not register what particular crops receive a watering in each month, it is not possible to furnish information regarding the average monthly area of each crop irrigated. The monthly *Sudhar* is no guide in this matter.

3295. (53) (a) Possibilities of expansion of area under cotton by enlarging canals.—The supply in the rivers would be sufficient till the end of September, to make it possible to enlarge canals.

3296. (53) (b) Effect of enlargement of canals on area under wheat.—Such enlargement of canals for increasing the area under cotton and other *kharif* crops generally is sure to have a detrimental effect on wheat because:—

(i) The culturable area being a fixed quantity, if the area under cotton is to be increased, the area under wheat must of necessity go down.

(ii) The supply in the rivers will be as low as now and the larger canals will pass the same discharge with less depth, which will result in loss of command in the *rabi* and naturally affect the area under wheat.

3297. (54) (a) Improvement in duty of water by remodelling outlets.—Equitable distribution along channels should certainly improve duty.

3298. (54) (b) Utilization of modules.—Kennedy gauge outlets are in use throughout on the Upper Jhelum Canal.

3299. (54) (c) Effect of remodelling of outlets on irrigated area.—The addition in area would be from ten per cent. to 25 per cent. and crops of all classes would increase in the proportion obtaining at present.

3300. (55) Fluctuations in river supplies and their effects.—The increase of the supply in rivers in the spring is more or less gradual, while the decrease in autumn is more or less sudden. But this does not affect the *zamindar's* preference for any particular crop especially in *kharif*. A diagram (Annexure II)* is attached for the Jhelum River at Mangla up to and including the winter of 1916-17.

3301. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—The area commanded by the Upper Jhelum Canal is fairly well provided with wells, but those on perennial distributaries are falling out of action, while those on *kharif* channels are maintained for the purpose of irrigating from, when the *kharif* channels are closed. The effect of introduction of perennial irrigation in all tracts where wells exist is to bring about the abandonment of wells automatically with the incoming of canal irrigation.

3302. (58) Cropping and causes affecting it.—A statement is attached (Annexure I) giving the percentages of area sown in the Division in pre-canal days and now. It will be seen that so far the introduction of canal irrigation on the Upper Jhelum Canal has had practically no effect on the proportion between *kharif* and *rabi* sowings, being 35 per cent. and 65 per cent. respectively. The proportion of wheat has, however, increased while gram has decreased, but other crops remain practically the same as before. In the *kharif*, there is a marked improvement in rice and cotton.

(2) This statement also shows that of the factors mentioned in this question, the only one which affects the problem is the water supply and that other factors are inoperative so far.

ANNEXURE I.

Statement showing percentage of different crops before and after the introduction of canal irrigation in the Gujrat District, Upper Jhelum Canal.

Name of season.	Name of crop.	PERCENTAGE.		REMARKS.
		Before introduction of canal irrigation.	Now.	
1	2	3	4	5
Kharif	Rice	1	4	Figures in Column (3) are from the Settlement Report and refer to pre-canal days. Figures of Column (4) have been ascertained from local officers and are fairly approximate.
	Maize	2	2	
	Juar	5	20.5 including Fodder	
	Bajra	14	1.5	
	Sugarcane	1	5	
	Cotton	2	2	
	Others	6	...	
	Fodder	4	...	
	TOTAL Kharif Crop	35	35	
Rabi	Wheat	39	46	
	Wheat & Grass	7	3	
	Oil seeds	3	1	
	Vegetables	1	4	
	Others	5	5	
	Fodder	5	2	
	Gram	5	...	
	TOTAL Rabi Crop	65	65	

* Published in separate volume of maps and plans.

Punjab.]

Mr. H. W. M. Ives.

[Continued.]

Mr. H. W. M. Ives called and examined.

3303. (President.) I have been on the Lower Jhelum, Lower Chenab and Upper Chenab Canals and I have a working knowledge of them. I am at present on the Upper Jhelum Canal where I am in charge of the distribution of the supply to the five canals. I consider that, on an average, the supplies available in the Chenab and Jhelum Rivers in the months of March, April and October are greater than or equal to the capacity of the five canals, namely, the Upper and Lower Jhelum, Upper and Lower Chenab and the Lower Bari Doab except in particular years like last year which was a particularly low year and also the year before. In these two consecutive years, supplies were very low. In fact, last year, there was a low river right away up to the 28th of March as far as the Jhelum is concerned. My diagram of the supply of the Jhelum River at Mangla shows that.

3304. (Mr. Ashton.) I think there is scope for a certain amount of enlargement of these canals, but in a year like last year (1916-17) enlargement without reservoirs would be useless. Doubtless enlargement would bring about a large increase in cotton, especially in exotic cottons. But increasing the capacities of canals would have to be done with caution. As regards enlargement, if you are going to remodel on the existing supply level, then the enlargement would be of no use when the river supply is low. It would not affect the existing command of lands, unless the present bed levels were kept and supply depths only raised. Personally, I think that enlargement would not be very excessive in cost if the canals were enlarged say up to ten, fifteen or even twenty-five per cent. But if we go in for anything drastic such as doubling the canals, it would not only be prohibitively costly but we should lose command at critical times when the rivers are low. I cannot say off hand what the cost would be of having two channels with an island band between but it would be considerable. This method of enlarging would be feasible but I do not see the utility of it, as water would not be available in early and late *rabi*. It would be much cheaper to enlarge the canals up to say 25 per cent. than to supplement the existing channels with new parallel channels. As to what the cost of increasing the capacity of the existing canals to ten per cent. or 25 per cent. would be, I have not worked the figures out myself but I hear that the Lower Jhelum Canal is going to be remodelled. A project for giving it better gradients and for raising the supply generally is actually being worked out. Increasing the capacity by ten per cent. I understand is going to cost 25 lakhs. But to increase the capacity of the existing canal 25 per cent. would add only another 14 lakhs. Judging from these figures, the expense of increasing the capacity of other existing canals by a quarter more would not be very great proportionately.

3305. The Woollar Lake Project which is now being worked out will have the effect of increasing the supplies available during *rabi*. We have sufficient supplies as a rule to put down the bulk of the *rabi* and the Woollar Lake reservoir would help to mature the area put down.

3306. I have no experience of lining of canals. On the Upper Jhelum, the seepage question generally is not acute at present; the spring level has not risen very much except in the immediate vicinity of the canal. I think that any cultivator would much prefer to get "flow" irrigation on existing commanded areas than to erect pumps and lift his water.

3307. As to the average discharge which the Woollar Lake scheme is supposed to give, speaking from memory, I think it will give 300 to 400 cusecs daily in the winter months. This can, however, be verified from Mr. Purves' Report.

3308. I do not think that the water rates have any effect on the *zamindars*, preference for any crop. The water rate on wheat has been greatly raised on the Triplo Canals, yet the cultivators put down a large area under it. I do not think it a safe proposition to charge for water per watering instead of per acre especially with our present staff. The present staff has quite enough to do without having to spot a crop that has been watered once, twice or oftener. It might be feasible with a largely increased staff but even then I think it would lead to corruption. It would be giving tremendous power into the hands of the Revenue staff.

3309. (Mr. Roberts.) In my written evidence I have shown the sale price of cotton (*deski*) as Rs. 5 per maund. This is the figure supplied me by my subordinates, and is only very approximate. I am referring to the Upper Jhelum where cotton is very little grown and where every thing is in its infancy and my figures are very rough approximations. If the price of cotton went up as high as Rs. 23, it would give the crop a fillip. I do not think a staple price of Rs. 10 per maund for cotton would alter the cultivator's preference for wheat because wheat is much more easily grown than cotton. It is on the ground for a shorter period and is not so subject to insect pests as cotton. If you are going to put down exotic cotton, the wheat area would be affected because it would be sown at the time of the wheat harvest. It would also require watering in October.

3310. I have no experience of American cotton. We only began irrigation on the Upper Jhelum canal in 1916. The area of American cotton on this canal in 1917 was 3,181 acres. I could not give off hand an estimate of the probable increase of American cotton under present conditions on the Upper Jhelum. 23,340 acres is the total area under cotton in 1917. I have heard of failures of American cotton near Chillianwala on the Upper Jhelum Canal owing to bad seed. I think myself that exotic cotton will grow on the Upper Jhelum. The soil is the best that I have come across. I have already stated in my evidence that if the water in the Upper Jhelum Canal were short in October, the cultivator could get over the difficulty by means of irrigation from wells. Wells on the perennial channels are falling out of use now. No *zamindar* cares to keep up wells if he can get "flow" irrigation but on *kharif* channels he gets considerable help from wells and they are maintained for the *rabi* crops on such channels. There seems to be a general idea that American cotton requires water in February. If, however, it is the case that a first watering is not necessary for American cotton until April, then I should say that the prospects of increasing the area under it on the Upper Jhelum Canal are considerable. February is a very critical month for wheat.

3311. I have made no observations in regard to the cultivation required for wheat and for cotton. I have not heard any opinion expressed by the *zamindars*. I think, under present conditions, the wheat harvesting operations in April are a serious factor against cotton cultivation. The question of labour is important for the labour is limited now. In most of the tracts on the Upper Jhelum Canal, labour has been denuded by recruiting and therefore it is now limited. That is, of course, a temporary condition. The cultivator's preference for a particular crop is only a question of which crop pays the best combined with which is the easiest to raise. It is only natural that people should go for that which is the easiest. Though cotton may require but little cultivation, it is affected by all kinds of diseases whereas wheat is not.

3312. I think that payment for water by volume would be a favourable factor in extending the cultivation of cotton. But we have got to arrive at a suitable module and to get the cultivator to accept that module.

Punjab.]

Mr. A.-S. GIBB.

Undoubtedly a system of payment by volume for water would do away with all the trouble connected with the revenue staff.

3313. I have served on the Sirhind canal. It is the case that on the canals in the Eastern Punjab, the cultivator very often hesitates to use canal water because for one watering he has to pay full rates. He therefore prefers to raise gram as, if the rains are favourable, he can grow it without canal water, but if water were paid for by volume, it would give him more liberty.

3314. (Mr. Henderson.) There is a small area under rice which is chiefly on *kharif* channels. I doubt if the cultivators would grow cotton on such areas even if rice cultivation was abandoned because the soil is very hard and only suitable for rice cultivation.

3315. On the Upper Chenab Canal in the Deg regions there are areas where cultivators have grown nothing but rice for years. It is very hard soil and seems to produce rice only. We have got no *kallar* on the Upper Jhelum Canal. The soil is very excellent throughout.

3316. *Deshi* cotton is sown in April and May. The cultivators wait until after the *rabi* harvest. If the sowing of American cotton could take place at the same time as the *deshi*, it would simplify matters and I think the *zamindars* would take to American cotton in preference to *deshi* as they could get a much better price for the former. The last watering that they give to wheat is in March. American cotton, if sown in April, would not clash with the watering of wheat but it would clash with the harvesting of wheat.

3317. I have noticed that wells tend to fall out of use on perennial canals. That is my experience both on the Upper Chenab and Upper Jhelum. Where there is any chance of getting perennial flow, the cultivators will not keep up their wells. A combination of perennial "flow" irrigation and wells is out of the question.

3318. (Mr. Roberts.) I should certainly be prepared to help in the distribution of the seed of American cotton.

Mr. A. S. GIBB, Executive Engineer, Upper Bari Doab Canal.

EXAMINED AT LAHORE, JANUARY 7TH, 1918*

Written statement.

VI.—IRRIGATION.

3319. (50) Experience.—I have been in the permanent service of the Punjab Irrigation Branch of the Public Works Department since October 1901 and during that time have held charges on the following canals:—

- Lower Jhelum (Open Canals and Construction).
- Upper Chenab (Construction).
- Kabul River, North-West Frontier Province (Open Canal).
- Lower Chenab (Open Canal and Research).
- Sirhind (Open Canal).
- Multan Inundation Canals (Open Inundation Canals).
- Upper Bari Doab (Open Canal).

Revenue assessment work is part of the ordinary routine of canal officers on all these canals except on the Multan Inundation Canals.

3320. *Irrigation as affecting the cultivation of long staple cotton.*—The position from an irrigation point of view seems to be that the substitution of American cotton for *deshi* cotton on a large scale, or the irrigation of a large new area of American cotton in addition to the crops of all kinds already grown, may involve a change in the seasonal distribution of the water-supply among successive months of the year. I understand that the sort of change that seems to be required is that roughly indicated in the diagram attached, Annexure I,* in which the full line represents the average supply taken by the canal month by month throughout the year under existing conditions, while the dotted curves show how this may have to be altered to suit American cotton.

(2) The most important aspects in this change of the form of the supply curve for the year are the extra supply required in the spring before wheat harvest and the necessity to keep high supplies running longer into the autumn than at present. In the early hot weather and monsoon periods, we can do pretty well what we like: in the former period, the canal supply is even now almost always in excess of the real demand, while, in the monsoon, there is water enough in the river to fill a canal of any size. October, February and March are the critical times because under present conditions irrigators use as much water as our canals can make available in those months.

(3) The average supply of a Punjab river at any time of the year does not by itself give complete information as to the supply available for irrigation. At all times of the year the river is liable, with more or less frequency, to bring down supplies far in excess of the capacity of any canal, but the liability to do this is very different at different times of the year. The supply in the river that is in excess of the canal's capacity is obviously not available for irrigation, so that the extent of variation from the average at different times of the year is just as important as the figure for the average itself. I have not got the figures for any particular river site available, but the attached diagram, Annexure II,† may be taken as fairly typical of the Punjab rivers in general. In this diagram, the lines of minimum and average supply are fairly definite, but it is impossible to assign any very definite limits to the maximum supply that may come down; the line drawn merely represents the limit of ordinary variations to be expected at any time of the year.

(4) The point I wish to illustrate is that the figure for average supply in the autumn has a somewhat different significance from the figure for average supply in the spring. The fall of the supply in the autumn is fairly uniform from year to year while the rise in the spring is extremely irregular. The spring average river supply is the average of figures ranging from the absolute minimum of the year up to six or eight times the average, while in October the range of variation is relatively small. Thus the supply that can be made available for irrigation can be made to approach fairly nearly to the average river supply in the autumn, but must always be much below it in spring. Therefore, if a canal, whose capacity is less than the October average river supply, be increased in size, there will be a considerable increase in the average supply rendered available for that month, especially in the first half of it; but the same increase in the capacity of the canal will cause a relatively much smaller increase in the available average supply for the spring months. This is shown clearly on the attached diagram, Annexure III,‡ which represents the actual figures worked out for the proposed

* Mr. Gibb's oral evidence has not been printed as he was unable to correct it before leaving India on sick leave.

† Published in separate volume of maps and plans.

Punjab.]

Mr. A. S. GIBB.

[Continued.]

site of a new head works on one of our rivers. Unfortunately, I have no similar data for any existing canal head but in this respect our Punjab rivers do not differ much from each other.

(5) The greater the canal's capacity, the more closely will fluctuations in its supply from one year to another, correspond to fluctuations in the river. This is not very important in October because the river does not vary much from year to year in that month but it is very important in February and March : no increase in the capacity of the canal will alter the fact that in the absence of winter rain the minimum river supply for the whole year will occur in these months. Moreover, those years, when the river is high in February and March, are, as a rule, the years of heavy winter or spring rainfall, when there is little demand for canal water and when American cotton will need it no more than other crops. So much is this the case, that I think that the time of the whole year, when an increase in the capacity of the canal will have the very least effect in increasing the supply rendered available for irrigation, is the spring period including February and March. The enlarged canal will just give the same very low spring supplies in the years when water is most wanted at that season, and will usually only make big supplies available when rainfall renders them unnecessary.

(6) In the attached diagram, Annexure IV,* are shown the curves of average supply for the six cold weather months of each of five large perennial canals. Generally speaking, during these six months the demand is in excess of the supply and the canals all take every cuase they can get from the river, except when occasional rain causes the demand to slacken. Of the five, the canal whose curve has the deepest sag relative to its full capacity is the Upper Bari Doab Canal. It has evidently a greater capacity, relative to its river supply, than any of the others. Its October supply is seen to be well below its full capacity, and in February it takes an average of only 2,000 cusecs in spite of its 6,700 capacity. Obviously no increase in capacity would be of any appreciable use to this canal. The Western Jumna Canal is very similar to the Upper Bari Doab Canal. The Sirhind Canal might benefit a little in October by an increase of size but with its present capacity for 8,500 cusecs it can only take an average of under 4,000 in February and March, so that no appreciable improvement can be expected there. Moreover the balance of the Sutlej supply is, I understand, almost completely allotted for new projects.

(7) The two remaining curves on this diagram are for the Lower Chenab and the Lower Jhelum Canals and refer to the period before the opening of the new tripo canals. They are both flatter curves than the others and, assuming that the Chenab and Jhelum Rivers vary similarly to the Ravi and Sutlej, the curves indicate that these two canals were of too small capacity to make as full use of their river supplies as the other three canals do : this is especially the case with the Lower Jhelum Canal. But this fact is just what made the tripo canals possible. With these three new canals in full working order, the curve for the Lower Chenab Canal will certainly have a deeper sag and take a form similar to the other three. The Lower Jhelum Canal, alone of the five, will probably still benefit to some extent by an increase of capacity which will increase its *kharij* area without, I think, greatly reducing its *rabi*. I understand, however, that the enlargement of the Lower Jhelum Canal has already been decided on.

(8) The foregoing discussion of the supplies our Punjab canals take from the rivers shows, I think, that there is, what I may call, a series of natural curves representing the available supply throughout the year. Each curve of the series corresponds to a certain canal full capacity. All the curves of these series have the same essential form ; only in each series, as the canal capacity increases, the sag of the curve becomes deeper, the drop in the spring becomes more gradual.

(9) Now, if we must assume that under present conditions the canal supplies in October, February and March are not big enough, compared with the supplies during the other months of the year, to provide the special conditions suitable to American cotton, then I think it is evident that none of the series of natural curves will meet the case. That is, an increase of the capacity of the canal will not do what is wanted. And it would appear that American cotton will require a decided distortion of the form of the natural curve. A distortion of the curve of the kind required can only be effected, I think, by storage of water ; supply must be held up when it is surplus to augment the natural supply at the special times, when it is needed.

(10) But is the assumption made at the beginning of the last sub-paragraph correct ? That is, is it true that during these two critical periods the curve of available supply exactly fits the curve of real demand under existing conditions ? So far as October is concerned it is true, because wheat will be sown up to the limit of the available supply in that month whatever it may be. But whether *rabi* crops really require all the water they are given in the spring is a question I do not feel able to answer. It seems to me, however, that it is extremely important with regard to American cotton that the right answer to this question should be found.

(11) The waterproof lining of canals, though in my opinion urgently necessary for other reasons, will simply increase the supply available for irrigation by a large but approximately uniform percentage all the year round ; but the essential form of the supply curves will remain the same. Indeed the application of any measures, which result in a general, more or less, uniform or proportional improvement in the supply at the field all the year round, will probably, I think, other conditions remaining as they are, produce conditions of water-supply suitable for a general all-round increase in the area of crops as already grown, but will not bring about an altered seasonal distribution of supplies especially favourable to American cotton.

(12) Without storage facilities, the curve of canal supply cannot, so far as I can see, be distorted in the way that seems to be required to favour American cotton ; and I think it is possible, though by no means certain, that, without this positive distortion of the curve by means of stored water, wheat and American cotton will always interfere with each other to some extent. But at the same time, I believe that a general augmentation of the supply available for irrigation involving an all-round increase in intensity of cultivation, especially where intensity is now low, will of itself be favourable for the cultivation of American cotton. I think a high intensity of cultivation generally makes for a higher standard of and more ambitious husbandry and really gives to the cultivator greater latitude of opportunity and a freer choice as to what he will do. These reasons for my view may not be very logical but cultivators are not entirely logical. It is partly a matter of mental atmosphere : when cultivation is intense, man seems, feels and acts as master of the circumstances ; but when cultivation is relatively sparse, opportunity seems more restricted and circumstances are felt to be in command.

3321. *Possibilities of a large increase in the area under American cotton.*—The extent to which the apparently competing interests of American cotton and wheat can be reconciled by purely agricultural methods and without any change in the seasonal distribution of water-supply, is a part of the subject I am not competent to deal with ; though I think the earlier sowing of wheat would probably help. Unfortunately the results, so far obtained on the American cotton estates on the Lower Bari Doab Canal, are not applicable, since the colo-

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nisation of the area to be served by that canal is still so far from being complete that the limitations of the water-supply have not yet become fully effective. For the purpose, however, of dealing with some of the other questions, on which evidence is invited, I will assume that this cotton-wheat difficulty, if real, can be got over, and that a general increase in the total of irrigated crops will make the inclusion of a large area of American cotton possible.

3322. *The alternative policies.*—I think it is important to distinguish between the two alternative policies put forward for attaining this end, namely (a) to increase the supplies drawn from the rivers or (b) to adopt measures to ensure that a larger proportion of the water at present drawn from the rivers shall actually reach the fields and be applied to them in the most useful way. From what I have already said, it will be obvious that I do not advocate policy (a) for general application; because it will not result in any appreciable increase in the spring supplies in the drier years. The bulk of the increased supply obtained by the adoption of such a policy will be confined to the monsoon period and will be chiefly useful in increasing the areas of Indian corn and monsoon fodder crops. The second policy (b) seems to me to be preferable, because it makes for an approximately proportional increase of water available for field irrigation all the year round. Some of the measures of this class are mentioned in the list of questions, namely,—

- (i) Waterproof lining of channels.
- (ii) Equalised distribution at outlets.
- (iii) Change in the charge for water.

To this list I would add—

- (iv) An increase in the intensity of irrigation, especially where intensity is low. [This will be effective only in the absence of (i) waterproof lining for channels.]

I will deal shortly with each of these in the above order.

3323. *Waterproof lining of channels.*—We have no really accurate data as to the exact loss of water by absorption from our canals, but for present purposes I accept the usual all-round rough figure of thirty per cent. of the head supply as being lost between the canal head and the outlet. The percentage lost is higher for the Western Jumna and Sirhind Canals, where the intensity of irrigation is very low, than for the Lower Chenab and the Upper Bari Doab Canals, where the intensity is much higher. It is the water that is thus lost that is the evident cause of water-logging. In my opinion, so far as the Doab canals are concerned, this enormous discharge of water into the under-soil simply must be stopped, otherwise large areas of the tracts concerned are doomed to become vast salt-marshes within the next two generations or so, and American cotton as well as every other crop will go out of cultivation. I consider the lining of channels is a necessary condition of the continued existence as agricultural land of the Doaba tracts.

(2) Apart from that aspect of the problem, however, the economic of waterproof lining resolves itself into the matter of the price of cement. (I attach no value to puddle or brown-paper linings and consider, cement concrete the only possible material). Taking a broad view of the national economics of the subject I am satisfied, from figures I have seen, that even with the present high prices of cement (i.e., taking the pre-war price of cement imported from England) the total value of the produce obtainable from the water saved will be such as to make it a thoroughly sound financial proposition for the country as a whole. I am also satisfied that if we can manufacture good cement locally in the salt range, where I believe all the necessary materials are available, at a cost approximating to the cost of manufacture in England, then the lining of the canals with cement concrete could be made to yield a commercial profit to Government from increased revenue alone.

(3) In my opinion, all the water that can be saved by the waterproof lining of canals can be efficiently used on the areas already served by the canals. In all cases—but more so in some than in others—the intensity of irrigation can, I think, be beneficially increased to the extent that would be rendered possible by lining our canals with their present head capacity. There are undoubtedly many outlets on which the intensity of irrigation is uneconomically high, but these are much more than balanced by the numerous outlets, where the intensity is inefficiently low. The average all-round intensities are nowhere so high as to preclude a large increase in the cultivated area without taking in any new land.

(4) To make lining a practicable measure, and to devise means for carrying it out without unduly interfering with existing irrigation are purely engineering problems, which have just got to be solved. They have not been solved yet; but they are, in my opinion, by no means incapable of solution.

3324. *Equalised distribution at outlets.*—Some years ago I made a special investigation of this subject, as the result of which I found that the duty, based on the discharge of the outlet, falls rapidly after the allowance of water per acre commanded exceeds a certain limit. It must be remembered, however, that duty takes account of all irrigated area as such, and has no concern with the kind of crop or the value of the outturn. I am now inclined to think that the point of maximum value of outturn per cusec used would correspond to a considerably more liberal allowance of water per acre than that which gives the maximum area irrigated per cusec. On the attached diagram, Annexure V,* which shows the curve of duty at outlets for different water allowances as actually found from pretty accurate observation of about a hundred outlets, I have shown in red what I think may be the form of the curve of value of outturn per cusec. This red curve is purely conjectural but the point I wish to bring out is, that so far as the outlet is concerned, if we only look at the area irrigated, we are apt to be misled into concluding that the less water we give the better; and I think many have been thus misled. I am sure this generalisation is not true, if we take the value of outturn as the criterion. Common sense indicates that there will be a certain allowance of water that gives the highest value of produce per cusec, and that the efficiency thus measured will fall off on both sides of that allowance; that is, as the supply becomes more liberal or less liberal; I believe, the falling off in efficiency is fairly decided on both sides of the best allowance, but probably more rapid on the side of low water allowance than that of high.

(2) The present extreme inaccuracy of our outlet distribution means that whatever the best water allowance may be, relatively few outlets get it; the majority are working inefficiently because they get either too high or too low an allowance of water. Where the intensity is already fairly high, the equalised distribution of outlets will cause a very marked improvement in the efficiency of irrigation as measured by the value of produce per cusec; but where the intensity is generally very low as on some parts of the Sirhind and the Western Jumna Canals, accurate distribution will not make so much difference.

(3) The only practicable way of obtaining equalised distribution appears to be by the use of module outlets, that is, outlets which give a constant discharge.

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3325. *Change in the charge for water.*—The obvious change which is required in the existing schedule of water-rates is to abolish it altogether. The reason why it is so difficult to answer the question whether wheat really needs all spring water it is given, is that the cultivator pays the same water-rate per acre whether he gives his wheat two or five waterings. The difference between little watering and much so far as the cultivator is concerned is largely a matter of the amount of labour he has to expend in cultivating his fields: to a large extent he regards the canal water-supply as a labour saving device; and is quite correct in doing so. But the effect of making the charge dependent on the area of crop and independent of the amount of water used is obvious; once a cultivator is committed to paying water-rate on his fields, he is perfectly right to go on putting as much water as he can get on to them. The only way to give the cultivator a bias in favour of economical irrigation (which does not necessarily mean using less water), that I can see, is to base the charge on the water used. The use of modulo outlets is, I believe, the only practicable way of making this possible.

(2) I am aware that an accurate statement of agricultural expenses and receipts shows the water-rate to be a relatively small and unimportant item in the account but agricultural accounts are always difficult to make up and their lessons are usually obscure. This is true even in the case of the accounts of business-like farmers in Britain, and the cultivator in this country, whatever else he may be, is not very business-like. That which is very apparent influences him more than that which is very real but less apparent. An acreage water-rate payable in cash and continually brought to the cultivator's notice by Government officials going through his fields, claiming hospitality in the village and thumb marks on a succession of brown-paper forms is bound to exercise an altogether disproportionate influence, simply on account of its extreme obviousness however small the value concerned may be in reality.

3326. *Increase in the intensity of irrigation.*—I attach two diagrams, Annexures VI* and VII showing the relations between the intensity of irrigation and the *rabi* and *kharif* duties based on *canal head* and *distributary head* supplies for five perennial canals, from which it will be seen that there is a very important increase in the duties as the intensity of irrigation increases. It will be noticed that duties based on the discharges of canals and distributaries, taken as a whole, behave in a way exactly opposite to the duties based on outlet discharges. This apparent paradox requires explanation. The duty intensity diagrams for whole canals and distributaries bring into prominence the fact that, where intensity of irrigation is low, the total length of canals, branches and distributaries required to take the water to each outlet is great; so that the length of channel from which water is being lost by absorption is much greater than it would be, were the same supply used for more intense irrigation. Thus when intensity is low, the amount of water that eventually reaches the outlet is much less than when the intensity is high assuming the same amount taken in at the canal head.

(2) On the watercourse, on the other hand, a small allowance of water per acre of commanded land stimulates the cultivator to spread it over the maximum area possible. There are usually many shareholders, the area of land is large, each holder has to get his share of what little water there is and so large an area of relatively low yielding crops is grown and the duty at outlets is high, probably too high to be truly economical, though the duty of the canal as a whole will be low.

(3) Increased intensity of irrigation, then, is simply a means of reducing somewhat the percentage of the canal head supply that is lost by absorption in canal channels; it acts by improving the ratio of total area of irrigation to total length of channels. Of course, if all absorption from canal channels is practically stopped by waterproof lining, the length of channel ceases to be a factor in the problem.

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Mr. A. W. M. JESSON.

Mr. A. W. M. Jesson, Executive Engineer, Irrigation Department, Lower Bari Doab Canal.

EXAMINED AT LAHORE, JANUARY 7TH, 1918.

Written statement.

VI.—IRRIGATION.

3327. (50) Experience.—I entered the Irrigation Department, Punjab, in October 1906; for the first year I was attached to a Sub-Divisional Officer partly on construction and partly on an open canal. In November 1907, I was transferred to the North-West Frontier Province, and was employed on the construction of the Upper Swat River Canal till April 1914. In April 1914, I was transferred to the Headworks of the Lower Bari Doab Canal and from there I was transferred in June 1915 to the Headworks of the Sirhind Canal where I remained till October 1915. In November 1915, I was transferred to the Ferozepur division of the Sirhind Canal, and remained in charge of Asabutar sub-division till June 1916. In July 1916, I was transferred to the Montgomery division of the Lower Bari Doab Canal, where I am now Executive Engineer. Thus most of my experience has been on the construction of canals, and my only experience of open canals is the eight months I spent in charge of Asabutar sub-division, and the last seventeen months during which I have held charge of the Montgomery division of the Lower Bari Doab Canal. During the last 25 months, I have had experience of ordinary canal irrigation assessment work, i.e., measurement of crops, and preparation of demand statements.

3328 (51) Wheat *versus* cotton.—On the Sirhind Canal, the cultivators preferred wheat to cotton; in fact, very little cotton was sown in my sub-division. The reason for this preference was that, at the time, the rate for cotton was normal, and nothing was known of American cotton in the sub-division of which I held charge. Further there are less risks attached to the cultivation of wheat; cotton is subject to more pests. The cultivator, I believe, takes this into account. He could make more profit out of his wheat crop, and it supplied fodder for his cattle.

(2) On the Lower Bari Doab Canal, the cultivators now prefer cotton to wheat as the price is so high that they can make much more profit out of it than they can out of wheat. This preference will, I believe, only remain as long as the present high prices continue. The cultivator will never give up his wheat, as he requires it as a source of food for himself and his cattle. He will, however, probably reduce his *pachetri* wheat, so as to have more water for his cotton. *Pachetri* wheat requires late watering when the water ought to be going to cotton sowings.

3329. (52) (a) Critical period in regard to water supply.—The critical period in regard to water supply on the Lower Bari Doab Canal is from the middle of October to the middle of April. During this period the canal will, in a normal year, be running in rotation with the other four canals. The commencement and end of the period must vary, depending on the rainfall. The most difficult month as regards water-supply for American cotton is October. During this month American cotton requires a lot of water, and at the same time a lot of water is required for the "watering before sowing" of wheat. If American cotton is to get the water, then wheat cannot have it, and the result will be *pachetri* sowing of wheat up till the middle of December. This will not be desirable. Again, if *pachetri* wheat is sown, it will require late watering in March when the water is required for cotton sowings. Under existing conditions, I do not see how the area of cotton can be much increased on the Lower Bari Doab Canal without detriment to the wheat crop.

3330. (52) (b) Watering of cotton.—The first watering after sowing for American cotton, should, I understand, be given about two months after the seed is sown. The average cultivator does not understand this, and will give the first watering after a much shorter period. It is difficult to say when the cotton is subsequently watered. It depends when the cultivator's turn comes. If he gets a turn frequently and has water to spare, he will probably water every fifteen days.

(2) The average cultivator probably puts about four inches of water on at each watering. If he would take the trouble to conserve his water, keep his water-course clean, and irrigate with *kal-kharis*, three inches would probably go as far as the four inches.

3331. (53) (a) Possibilities of expansion of area under cotton by enlargement of canals.—During the summer months, i.e., June to September, there is ample water in the rivers for a large expansion of the area under cotton, but I do not consider that it would be possible to enlarge canals to take this water solely for the purpose of increasing the area under cotton. Suppose the Lower Bari Doab were enlarged, there would be no difficulties in the *kharrif*, but the difficulties would come in the *rabi*. At present the Lower Bari Doab Canal in an average year will run two-fifths time, i.e., twelve days per month in the *rabi*. In a year when the rivers are very low, it will probably be only possible, to get ten days. This is, I consider, the minimum period of flow for which a canal works efficiently in the *rabi*. All the cultivators' *waris* are based on a ten day period. Now suppose the canal was enlarged, this period of flow during the *rabi* would have to be reduced, and the quantity of water increased during this shortened period, as it is always desirable to run channels with their full designed supply. This would not be satisfactory. I believe that irrigation could not be satisfactorily carried out, if the periods were reduced to less than ten days.

3332. (54) (a) Improvement in duty of water by remodelling of outlets.—I am unable to say to what extent the duty on a channel would be improved by equalising the distribution of supply between the upper and the lower outlets, but it would be most certainly improved for the following reasons.

(i) If an outlet is drawing off more than its share of water, this surplus will be used in two ways, viz :—

(a) To sow a larger area than the permissible area.

(b) To give unnecessary water to crops.

(2) To improve the duty of a channel, it is the latter that has to be stopped. At the same time, when remodelling outlets, the object to be aimed at is to give each outlet its designed discharge on which it is calculated that the cultivators can irrigate and mature their permissible area of crops.

(3) I am now watching a distributary on which the outlets were remodelled at the beginning of last *kharrif*. In spite of the reductions in the upper outlets, I believe that the area irrigated this *rabi* will not be less than the area irrigated last year, although the water has been considerably reduced. The reason for this is that

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the cultivator will conserve his water and will not give any unnecessary waterings. The water saved will be used lower down the channel to increase the irrigated area and thus increase the duty.

(4) If a cultivator can get water, he will put it on this crops whether they require it or not. During the last few days I have seen water being given to wheat which is only just sprouting.

3333. (54) (b) Utilization of modules.—The only satisfactory way of equalising the distribution of water is, I believe, by the use of modules or semi-modules. I have no experience of the former but I have a little experience of the latter in the form of the Kennedy gauge outlet. This has recently been fitted on one of the channels in my division. The outlets work well provided there is at least 0.5" command and this is not difficult to get. These outlets prevent the cultivator drawing off more than his share of water, which he can easily do with the ordinary type of outlet by deepening his water-course.

3334. Suggestions for improvement of duty of water.—Whilst on the subject of duties, I should like to say that, in my opinion, these could be greatly improved by—

(a) The sale of water by bulk for irrigation.

(b) Universal adoption of the system of irrigation with *kal-kharis*.

(2) Rule 9 of the Canal Act empowers the Divisional Canal Officer to levy punitive rates on all irrigation done without *kal-kharis*. The rule, however, makes a proviso that either the Divisional Canal Officer, the Sub-divisional Canal Officer, or the Canal Deputy Collector, must certify by personal inspection that the field has not been divided up in accordance with the rule. Now it is impossible for these three officials to inspect more than a very small percentage of the irrigation during a crop, and the result is that, in most cases, rather than take the trouble to make the *kal-kharis* and irrigate economically, the average cultivator will prefer to run the risk of being caught and having to pay the punitive rate.

(3) Irrigation can be increased with our present supply of water, if the cultivator is made to irrigate economically. An experienced *zilladar* recently told me that he believed we could increase our irrigated area by fifty per cent, if the use of *kal-kharis* were universal. I think, however, he has pitched his figure too high. I would put it at twenty per cent. This would be a step in the right direction, and I, therefore, think that the rules regarding the use of *kal-kharis* require revision, with a view to making this system of irrigation more common and thus increasing our irrigated area, and increasing our duty. The water saved by the adoption of efficient methods of irrigation would probably be used in the *kharif* for the extension of cotton and in the *rabi* for wheat.

(4) As regards the sale of water by bulk, there can be little doubt that this method would considerably increase the duty of a channel. The cultivator will have to pay for the amount of water he receives and there need be little doubt that he will use it to the best advantage. He will be as careful with it as a well-owner is who irrigates from his well.

3335. (55) Fluctuations in river supplies and their effects.—On the whole it may be said that in an average year the rise and fall of the rivers in spring and autumn is gradual. Please refer to "Statistics of irrigation, water distribution, and working of distributaries of the canals in the Punjab" for any year. At the end of the volume, diagrams are given showing the rise and fall of the rivers. The rise and fall will not affect the crops sown.

3336. (58) Cropping and causes affecting it.—Taking a holding of 100 acres on the Lower Bari Doab Canal, the permissible area to be irrigated during the year will be 65.5—say 66 acres. 39 acres will be irrigated in the *rabi* and 27 acres in the *kharif*.

A good cultivator will divide his crops up as below—

Rabi.	Kharif.
3 acres toria.	13 acres cotton.
3 acres sag or senji.	4 acres sugarcane.
5 acres gram.	4 acres makki.
28 acres wheat.	6 acres chari or gwara.

A bad cultivator will probably sow the following:—

Rabi.	Kharif.
10 acres sag or senji.	8 acres cotton.
7 acres toria.	9 acres bajra.
22 acres wheat.	3 acres makki.
	7 acres chari or gwara.

The crops a bad cultivator selects are those which require less attention on the part of the cultivator. It will be noticed that he does not cultivate sugarcane as it requires a lot of attention, and the ground requires a lot preparation.

(2) The water-supply will not affect the area of the fodder crop sown. Any surplus or deficiencies will probably affect the cotton crop in the *kharif* and the wheat crop in the *rabi*.

3337. (59) Practicability of lining canals.—I have had no experience of actually lining canals, but I carried out certain experiments on cement concrete slabs for lining canals when I was at the Headworks of the Sirhind Canal. As a result of these experiments and of my 7½ years' experience of the construction of canals, I am of opinion that the lining of canals with cement concrete is perfectly practicable. I have roughly worked out the cost of lining a distributary with a head discharge of 178 cusecs. It would cost about Rs. 4,00,000 including establishment and telegraph and postage charges. This works out to Rs. 7-4-0 per acre of culturable area. Now the cost of constructing distributaries is calculated at Rs. 2-2 per acre for the Lower Bari Doab Canal. I have no figures to show the total cost of the canal worked out on the basis of an acreage rate. I would propose to do all lining with cement concrete laid *in situ*. Excellent cement is available in India and excellent aggregate and sand are available from Pathankot.

(2) The above figure may seem large when compared with the original cost of the channel but let us consider the question from two other points of view—

(a) The value of the water saved by lining.

(b) The benefit derived by the prevention of seepage from channels.

(3) Consider (a) first. The absorption of the above channel worked out in accordance with Mr. Woods' rule comes to 23 cusecs. Now, on the Lower Bari Doab Canal, it is estimated that 2.62 cusecs at the outlet

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head will irrigate 655 acres annually. Therefore, 23 cusecs will irrigate 5,750 acres annually. Taking the average water rate at Rs. 4 per acre, the annual revenue from this saving of water will be Rs. 23,000 in water rate alone. Now at 4 per cent. the interest charged, on the capital cost of Rs. 4,00,000 will be Rs. 16,000. Deducting this from Rs. 23,000 we have left Rs. 7,000. Taking the cost of repairs at Rs. 4,000 annually we still have Rs. 3,000 left.

(4) Now consider (b). We know that a large amount of water is absorbed into the soil in the form of seepage from our present unlined canals, and that this water tends to raise the subsoil water level, until it eventually becomes so high that the land becomes waterlogged. It is most desirable to prevent or at any rate reduce this tendency to waterlogging, and, therefore, it seems to me that expenditure of money on this account, i.e., as a protective measure, would be justifiable. If a certain amount of the cost can be debited to protective works, then the profits to be derived from the sale of the water saved by lining will be increased.

3338. (61) Enlargement and lining of canals.—Should it be found desirable to enlarge a canal it would, I think, be possible to line it in conjunction with the enlarging, provided the canal was subject to rotational closures. The lining of distributaries could easily be carried out in rotational closures. Water for existing irrigation would have to be carried in the existing channels. This could be done by suspending the lining work whilst the canal was in flow. This would mean that during the *rabi*, which is the working season, lining work could be carried on for about nineteen days in the month. During the remainder of the time the labour would be employed in getting material, etc., ready for the next closure.

3339. (62) Effect of lining canals on seepage problems.—I have treated this question in my reply to question 59 (Paragraph 3337). I may add that I believe the seepage from channels would be nil if they were lined with cement concrete. This will reduce considerably the rise in the water-table, and the only source left, which will tend to raise the water-table, will be the wasteful methods of cultivators. If irrigation with *kal-kharis* is more universally insisted on, the waste of water will be very little.

3340. (63) Effect of lining canals on supplies.—I have partially treated the subject of this question in my reply to question 59 (Paragraph 3337). I have shown that seepage will be saved. This saving would be practically the same in summer as in winter. I would also point out that a lined canal will carry very much more water than an unlined one of the same dimensions.

(2) I consider that the question of lining canals with cement concrete should be very carefully investigated, and I should like to see a complete distributary lined. I only advocate the use of cement concrete. I do not believe in cement and sand plaster or any other lining materials. I believe that expenditure on lining with cement concrete will be justifiable.

3341. (64) Suitability of water rates.—With the existing rates, I believe that the water rates charged have no effect on the cultivator's preference for a particular crop. At present I do not consider that any change in the rates is called for.

Mr. A. W. M. JESSON called and examined.

3342. (Mr. Ashton.) Kennedy gauge outlets have been installed on 14-L distributary so as to give a discharge of 2.62 cusecs for a thousand acres of cultivable commanded area. That is the projected allowance which has been fixed for the Lower Bari Doab Canal. If there is to be a reduction, it will be for all outlets. In zone A, the discharge is 2.62 cusecs and in zone B, it is 2.26 cusecs. The critical period in the water supply on the Lower Bari Doab Canal is from the middle of October to the middle of April but last year it went on to the end of April. I have forty Kennedy gauge outlets on 14-L distributary. They will probably be gradually introduced all over the canal but we cannot put them in at once all over the canal as they are expensive.

3343. The Lower Bari Doab was opened in 1914, but there was very little irrigation done in 1915-16. The canal is not yet fully developed. The water rate for wheat is Rs. 5 and for cotton is Rs. 4. We are giving free remissions for the first two crops. I have no distributary in my division which is fully colonised at present. We cannot do much more until after the war as so much land has been allotted to the military.

3344. The lining of the Lower Bari Doab Canal would have the effect of preventing all absorption throughout the year. We should have the water thus saved available for cultivation all through the critical months. Lining would prevent water-logging. It is difficult to say what the percentage of water lost through absorption amounts to. It is about twelve per cent. on the distributaries. On the Lower Bari Doab, we generally have closures for nineteen days every month from October to April and we could line the canal during that time. The length of the closure depends on the water available in the rivers. In normal years, we would be running for $\frac{2}{3}$ ths of the time in the *rabi*; the rest of the time the canal is closed. This year there was so much water that we had to close down as there was no demand for it. We could not line the main canal unless we closed it. The keenest demand on the Sirhind is undoubtedly in the *rabi*. There is not much *kharif* irrigation. In the Lower Bari Doab, I should say there is very little difference between the *kharif* and the *rabi*. The proportion is supposed to be sixty *rabi* and forty *kharif*, but it will probably work out at half and half. If an extra supply is wanted to raise the *kharif* percentage from forty to fifty without enlargement, then the canal will have to be lined. If it is lined, there will be plenty of water to raise the *kharif* percentage. The proportion between *kharif* and *rabi* actually depends on the supply in the *rabi*. On the Lower Bari Doab Canal, the projected ratio is forty *kharif* sixty *rabi*. If it is to be changed to one *kharif* and one *rabi*, the canal will have to be enlarged or lined. I do not think the *rabi* area would decrease below one half of the permissible annual irrigation no matter was given in the *kharif*. If you increase the water in *kharif*, the *zamindar* will increase his intensity. An increased water supply in *kharif* will have the result of increasing the *kharif* provided, of course, the land is available. The intensity is now 65½ per cent. of the cultivable commanded area but it could be increased to 70 or 75. All the area commanded by the canal will eventually come under irrigation. The cultivator might reduce his *rabi* area slightly.

3345. (Mr. Roberts.) There would not be any objection from an irrigation point of view to increasing the intensity, on the Lower Bari Doab Canal to one *rabi* and one *kharif*. I do not see how the canal could be enlarged very well without remodelling the bridges. Lining would not require remodelling of masonry works and the existing ones could be used with only slight alterations which would be easy enough. With cement lining, it is probable that absorption would be negligible and you could have a steeper bed slope.

3346. My general impression of cotton on the Lower Bari Doab is very favourable. It is a popular crop and next year there will be very little *deshi*. The total area of cotton in my division is about 50,000 acres.

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I have not got the exact figures, but I think about 26,000 acres are American. I do not think one would be justified in estimating for an area of 120,000 acres under American cotton next year on the Lower Bari Doab. That would be a jump of about 40,000 acres. A lot depends on the water. You may get a large area under cotton but the question is whether it could be matured. Will they get water in October? They must have water in October. Our experience on the Lower Bari Doab this year was that they were watering right up to December. It keeps off frost to some extent. The demand was very low because they had a lot of rain in September.

3347. As to the assistance which the Canal Department gives in the distribution of seed; in past years it has been considerable, but I do not think we can keep it up indefinitely. The *zilladars* who distribute seed have their hands full and they have to leave other work undone, such as the inspections of the work of *patwaris*, etc. They have to go round to get the cultivators to buy seed. Later on, the cultivators may come in of their own accord and buy the seed and then there will be no trouble, but at present we have to press it on them. From the results this year, I think the *zamindars* will undoubtedly take it willingly next year. We have not got the indents in yet but I think the amount to be distributed will be very high. We can manage it for a year or two but I do not think that the Department ought to do it for many years. Private enterprise ought to do it. Later on when the colony is more developed, men like *lambardars* and *zaildars* ought to distribute the seed not only of cotton but of other crops.

3348. I would especially lay stress on the sale of water by bulk. Under the *kal-kiari* system, the main water course runs down one side of a rectangle of 25 acres. There are smaller branch water courses, running down the middle of each *killa*-plot. An acre is divided into eight *kanals* and one *kanal kiari* is the unit for irrigation. The *zamindars* are supposed to irrigate the first *kiari* and then to close its *nakka* and then to irrigate the next and so on. But they cut the *bunds* between the *kiaris* so as to irrigate two at once and so waste water. The *kal-kiari* system of irrigation does mean extra labour but a *zamindar* can do it perfectly well. He will not bother about it. On the Lower Bari Doab Canal I tried to keep the *chaks* about 500 or 600 acres with a discharge of one cusec and a half. If water were sold by bulk the cultivator would make his own *kal-kiari* system and he would work out the system which paid him best. I believe an experiment has been sanctioned in selling water by bulk to Sardar Jogendra Singh.

Mr. H. W. NICHOLSON, B.Sc., A.M.I.C.E., Executive Engineer, Sirhind Project Division, Punjab.

EXAMINED AT LAHORE, JANUARY 7TH, 1918.

Written statement.

VI.—IRRIGATION.

3349. (50) Experience.—The witness, prior to appointment to the Punjab Irrigation, served for two years in the Admiralty Director of Works Department, Haulbowline Dockyard, 1903—1905.

(2) On appointment to the Punjab Irrigation in 1905, he has been employed :—

- (1) *Patiala Division, Sirhind Canal, 1906—four months.*—Survey work for a project that never matured but during which information was gained which later led to the conception of the present project on which witness is engaged.
- (2) *Upper Chenab Canal, 1906-07.*—Construction work on main line in three Divisions.
- (3) *Lower Jhelum Canal, 1907-08.*—Irrigation in *bar* and *khadir* tracts.
- (4) *Upper Jhelum Canal, 1908-12.*—Construction work of main line and torrent crossing on border of Kashmir State and Gujrat District.
- (5) *Upper Jhelum Canal, 1912—four months.*—Personal Assistant to R. E. Purves, Esq., Superintending Engineer.
- (6) *Sirhind Canal, 1912-15.*—Sub-Divisional Officer, Headworks, held divisional charge of Ludhiana division three times. Rupar division twice. Ferozepur division once and finally the Ludhiana division. Permanently posted to the Project Division.
- (7) *Project Division, Sirhind Canal.*—1915 to date.
- (8) The following tours have been made :—
1913, to Bengal to see Sarda Ganges Bridge under construction.
1916, to all the Headworks in the Punjab Province.
1917, to the major dams and storage reservoirs in Bombay and Madras Presidencies and Gwalior State.

(3) Generally it may be said that the witness has had most experience of design and construction of irrigation works of magnitude, with experience of irrigation assessment work as Sub-Divisional Officer and Executive Engineer on two canals, the Lower Jhelum and Sirhind Canals.

3350. *Method of approaching the question.*—Witness has been particularly struck by the fact, in the working of this Department, that questions such as the one now under consideration cannot be effectively dealt with. The highly trained and paid officers of this Department are all employed in keeping an enormous machine, consisting of subordinates and petty officials, clean and in working orders; and complying with irksome rules of procedure, which so absorbs their energies that they have no opportunity left to take up or consider any other questions than those they are compelled to; this applies without exception from the lowest to the highest Gazetted Officer. The handling of all these questions involves the statistical analysis of enormous masses of figures. There is no man in the Province now, owing to the increase of irrigation, who can, from personal experience, give an opinion of the cause and effect of the economic changes which are taking place.

(2) Since the witness joined this canal he has taken every opportunity to collect all the statistics that exist in connexion with it and analyse them. Since holding charge of the Project Division, the field has been widened, as statistics, covering the broader principles of the remaining canals of the Province, have been collected and analysed, owing to the necessity of obtaining reliable data on which to base the design of the Sirhind Project and trace its future development.

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3351. *Statistical statements attached.*—For the question of cotton growth the following statistical diagrams* are attached—

(a) Diagrams showing crops grown on all major and minor canals of the Province, collectively and individually.

(b) Diagrams showing the ten daily supplies on the Sirhind Canal and branches.

3352. (51) *Wheat versus cotton.*—The crop diagrams speak for themselves as an inspection shows.

(2) In the table, Annexure I, the canals are placed in order of proportion of cotton area to wheat area. The water rates charged on the canal for the two crops are given. From this it will be noticed that—

(a) The proportion is not affected by the pitch of the water rates.

(b) All the inundation canals have a greater proportion of cotton than the perennial canals, except the Western Jumna Canal and Upper Bari Doab Canals.

(c) The table, Annexure II, shows the relation between wheat area compared to cotton areas on the perennial canals and the area of each crop cultivated per cusec of head capacity and per cusec of mean supply.

(3) The canals are arranged in order of proportion of cotton grown to wheat and it is at once evident from the table that *wheat and cotton are antagonistic crops*, that is, as the wheat duty increases the cotton duty decreases.

(4) The Sirhind Canal is put separately below, as the canal has several characteristics entirely different from the other perennial canals:

(5) The reason for the antagonistic connexion between wheat and cotton duty, is due to the fact, that they both have common times for demand for water. To sow cotton, water is required at the time when wheat wants its last watering and to mature cotton its last waterings are required when water is required for sowing wheat, so that it is quite evident that cotton is cultivated at the expense of wheat, as the supply of water is limited at these two particular periods. On the Sirhind Canal, the wheat crop matures earlier than on the Colony Canals and the cotton sowing time on the Sirhind Canal clashes with the wheat reaping time.

(6) It is seen that wheat is cultivated in a far greater proportion than cotton on the whole, and that one crop cannot be increased except at the expense of the other, under present conditions; the question is now what determines the balance?

(a) Water-rates appear to have no effect;

(b) Nature of cultivation, extension or intensive.

Cotton requires much more labour in cultivation and where labour is scarce or the holdings larger there is less cotton grown.

(7) *On the Colony Canals*, the soil is such that comparative little weeding is required, and for cotton picking there is a fair supply of labour available, but for picking, the labour takes one-fifth or one quarter of the crop, and the tendency is for the cultivators to be disheartened to see so much of their profits go to the picker and not cultivate as much as would otherwise be the case, as they cannot get the full profit. The growth of *toria*, however, encourages the growth of cotton, as the *toria* is said to leave the land in a loose condition so it is easily prepared for cotton.

(8) *On the Sirhind Canal*, the conditions are very different; cotton is practically only grown in the *powadh* tract, which may be defined roughly as the top twenty miles of all the branches. In this tract the land is stronger than further down the branches, and the holdings smaller. Even sweepers and *chumars* hold their own land. With small holdings, the cultivator has to work more to get his living out of the land, and under such conditions cotton is grown, as the profits are greater though the labour required is more. On this canal, the cotton needs more weeding, and owing to local customs arrangements for picking are not as simple as on the Colony Canals. On the Sirhind Canals lower down, the holdings are larger, the ground lighter, and but little cotton is grown; what little is grown is usually as a mixed crop of cotton and melons, sufficient for household use. It is said that cotton cannot be grown in this tract without manure, which according to local custom is used for fuel to the detriment of the land. On the Sirhind Canal, the cultivators are a more or less simple people whose wants are few. They grow their wheat as their main crop, and in the hot weather, with all their wants supplied, they prefer to lead an easy life, rather than undertake a strenuous life in the heat. In addition to *makki*, they just grow sufficient fodder crops, *chari*, *mung* and *moth* for their cattle, of which there are many more than on the Colony Canals, and the straw obtained from the wheat on the Sirhind Canal is less than that on the Colony Canals. Were the cultivators in this tract in more straitened circumstances, they would undoubtedly have to undertake the cultivation of more paying crops which involve more strenuous labour.

(9) Generally cotton is more sensitive to water-supply and insect pests, which makes it a more uncertain crop than wheat in amount of produce, and again its market price makes the profits more uncertain. Cotton furthermore cannot be held over by a *zamindar* for a better market price as it deteriorates whereas he can store his wheat without fear of damage. So long as a man can cultivate sufficient wheat to cover his household expenses, he will plant it in preference to cotton. Doubtless the desire is to increase the area under cotton but it has been shown that to increase the area under cotton causes a decrease in the area under wheat.

(10) It appears, therefore, a question for consideration as to the economic desirability of trying to push the cultivation of cotton in the Punjab when it involves a decrease in the area under wheat. Doubtless in other parts of India where wheat is not grown, the economical difficulty referred to above would not hold.

3353. (52) (a) *Critical period in regard to water supply.*—The critical periods of supply for the Punjab Canals are the end of the cold weather before the Himalayan snows start melting and the hot weather rise in the rivers occur, and again in the autumn when the rivers fall. The Jumna River has another critical period, as the catchment in the perennial snows is so small, that the melting snow water runs off before the monsoon bursts, and there is frequently a shortage of supply in June. Regarding the amount of water taken by cotton, witness has no figures, but it is known that it requires much more water in all than the average crop, and also requires a shorter period between successive waterings.

(2) A diagram (Annexure XI)† is attached showing the authorised supply of the Sirhind Canal, main line and the ten daily average discharges in each year, for ten years 1907–1916. The blue intercept shows the discharge utilized and the red intercept the unutilized capacity of the canal, when surplus water

* A selection only of these has been printed.

† Published in separate volume of maps and plans.

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is passing the Rupa Headworks to the sea. From this diagram one will be struck by the poor demand on the Sirhind Canal during the *kharij*. This is due to the fact stated above that the cultivators make sufficient for their needs out of their *rabi* crops.

(3) In the early years of the canal, owing to the fact that there was little cotton on the canal, the annual closure took place in April and May, as it interfered least with the nature of the cropping in force. On this canal, owing to the instability of a large superpassage on the main line which necessitated annual attention, a closure was more necessary than on other canals; later, the safety of the work having been secured, the closure has not been so essential; since 1910, only one year, 1912, has there been an April closure, and since 1912, no April-May closure has been permitted, in accordance with No. 212 R.L. of 21st February 1913, owing to the desire to encourage cotton cultivation. An inspection of the crop diagrams (Annexure VII-X)* will show it has not had much effect on the British branches, but in 1913 it showed an effect on the Native States Branches, which has since, however, passed away. Since 1914 witness has brought to the notice of the Administrative Officers that the Sirhind is the least efficient canal in the *kharij*. This is partly due to the fact, that owing to the nature of the soil and favourable rainfall, the cultivators endeavour to raise *barani* crops, which accounts for the demand in September and October not requiring the available supply in the river, in such years of favourable rainfall.

(4) The endeavours to stimulate cultivation of cotton, have been met with the following objections on the Sirhind Canal:—

- (1) It has not been customary to grow cotton in the past.
- (2) In the lower reaches the soil is so light that the young plants get cut to pieces owing to sandstorms.
- (3) The soil is light and needs manure for cotton cultivation.
- (4) The cultivation in the lower reaches of the canal is extensive rather than intensive, and the cultivators are satisfied with the profits of their crops requiring less labour.
- (5) That the growth of cotton is too much of a gamble for a poor man, the outturn being liable to be very little, owing to calamity, and the price of the produce being very uncertain, and again it cannot be stored and has to be sold at the market price at the time.
- (6) Owing to the large wheat area, maturing early at the time of cotton sowing, agriculturists are fully employed in harvesting and have not the opportunity to sow cotton.

3354. (53) Possibility of expansion of area under cotton by enlargement of canals.—On the Sirhind Canal, the diagrams show that there is scope for the increase of cotton area, without any need to increase the capacity of the canal.

(2) Rather than undertake the costly enlargement of a large canal system, it would be much more satisfactory to be able to have a certain supply of the river held up in a storage reservoir, so that the drop in supply at the critical time in the autumn would be avoided, and a balance of supply stored to give the canal the requisite discharge before the river rose naturally. It is on the principle of storage that the whole project on which witness is engaged, is based. The general principle of the Project is to command and irrigate forty per cent. of the whole tract of land between the Sutlej and the Jumna, which is physically within command; storing the necessary *rabi* supply in the Bhakra Reservoir on the Sutlej, which will hold over 2,500,000 foot acres of water, or 7,000 cusecs discharge for six months.

(3) The *kharij* supply for the extensions in the river Sutlej is sufficient. In tracts, such as exist on the Western Jumna Canal, where the percentage of irrigation at present provided is less than forty per cent. it will be increased to that figure.

(4) From the point of view of increasing the area under cotton, this Project appears to be the best arrangement that could be devised. With the whole river Sutlej supply controlled by an immense reservoir, the control of the supply in the canals would be in the hands of men and not nature, so that at the critical periods the canals could run full capacity, irrespective of the natural supply in the river.

(5) It has been shown that the Sirhind Canal does not require any alteration to take up a large area of cotton; to enlarge other canals to be able to carry more water at the critical periods for cotton cultivation would be of doubtful expediency, because the increased capacity could only be utilised for such a short period, when the supply in the rivers is sufficient, and then there would still be the difficulty of tiding over the first and last cotton waterings, especially in the case of American cotton. The enlarging of the canal would affect wheat or cotton, according to the existing customary cropping, which is governed by the principles enumerated above, in paragraph 3253.

3355. (54) (a) Improvement in duty of water by remodelling outlets.—This question is one which is so complicated and technical that it is not proposed to consider it. Suffice to say that there is an enormous scope for conservation of water and increase of efficiency by regular distribution and lining of channels. Were distributaries concrete lined, the difficulty of keeping them in constant regime would vanish. The difficulty is the question of expense; but it is maintained, for a more efficient service a higher water rate should be imposed, apart from any other considerations. Under such conditions many improvements would be permissible, which are now cost-bared. At present, in the Department, every anna of cash expenditure has to be exactly accounted for, whereas there is little or no accounting for the water used, and what accounting for water there is, is subject to less check. Were a rigid system of accounting for the water used, introduced, the statistical analysis of the results would make an advance in efficiency far more easy than leaving it to some fetish. To give exact or approximate figures of the increase of irrigated area, due to more efficient distribution, is nothing more than surmise, because the object has not yet been attained.

3356. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—In most of the inundation canal tracts it would be feasible to supplement the hot weather supply by wells for early and late sowings as spring level is generally high. At present their cotton is matured by the moisture of a final heavy flooding. The general tendency is now, as soon as canal water is available, to dismantle a well. This shows that the canal water-rates in no way approach the market value of water to the cultivator.

(2) Taking the area covered by the present Project, there are large areas with a high spring level, in which the cultivation of cotton could be done by well irrigation and a large number of wells actually exist.

(3) On the map of the Sutlej Dam Project submitted for the inspection of the Committee the horsepower at all the falls on the main and branch canals is shown in vermilion. From this it will be seen that

* Published in separate volume of maps and plans.

† Not printed.

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there is over 50,000 horse-power unutilised at about eighty sites. The fact that no attempts have been made to utilise this power seems to draw attention to the backwardness of the development of the country. With an engineering staff, many of whom have little or no mechanical training, it may be difficult to put up individual power installations; in the past, this has been the strong argument against the development of power from canal falls. It is, however, argued that if the power units were standardised, and the whole question of power put under an independent officer, the proposition assumes quite a different aspect. From the falls, electric power would be generated to supply water from tube wells. At the same time, power would be used for cotton ginning and pressing, corn grinding, oil seed crushing, etc.

(4) In cases where spring level was so low as to make pumping an impossibility, there would be no need to develop electric power, but simply utilise the power at site by shaft and belt transmission. Witness believes that development along these lines would improve the economic conditions of the tracts effected, as the cultivator and his cattle would have more time to devote to the cultivation of the soil, instead of being employed in purely mechanical work. A consideration of other canal tracts would reveal similar conditions.

(5) One other condition here deserves consideration, that is, in ensuring the oil, which has been discovered in the north of the Province, shall be devoted to the economic development of the Province, and not to the piling up of a fortune for a capitalist. There are many tracts where, with a cheap liquid fuel supply, tube wells would revolutionise their economic condition, making available for cultivation of higher quality crops such as cotton, the labour which otherwise is expended in raising the water required for cultivation.

3357. (56) (c) Tube wells.—Witness has sunk four tube wells, but not for irrigation purposes, and he is convinced that their future is but little appreciated and that their use is not being developed sufficiently rapidly.

3358. (56) (d) Construction of weirs.—The construction of weirs on rivers, *that have already had their critical period supplies utilised in canals further up*, seems to offer small but little advantage in developing cotton; the whole question is one of supply in the "cotton versus wheat" critical periods, and this can only be avoided by either supplementing the river supply by well irrigation or storage of flooded waters in the hills.

3359. (58) Cropping.—Witness has obtained the following figures, by enquiry, as applying to the Ludhiana District. A holding of 100 acres would be given to sub-tenants at a rate of twenty acres per plough; and the probable cropping would under favourable condition be:—

$\frac{1}{2}$ acre sugar-cane 1 auro cotton 2 acres makki. 1 acre melons, etc. 4 acres chari, bajra, followed by 4 acres gram. 6-7 acres wheat. 1 acre sarson.	} followed by 3 acres serji.
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3360 (59-63) Lining of canals.—Witness had been connected with this question since 1912 and has had to deal with the execution of such work on the Sirhind Canal. Personally he is of the opinion that nothing will beat the American practice of a concrete lining. It has been shown to be more than four times more efficient than clay puddle. It also has the advantage that maintenance charges practically vanish.

(2) The lining question divides itself into—

Lining new canals.
 Lining existing main line.
 Branches.
 Distributaries.

(3) In the Sutlej Dam Project, on which witness is engaged, it has been decided that the main line and major branches will be constructed in the original case with a concrete lining, as much can be saved in costs, owing to a much smaller channel being necessary, as advantage can be taken of the decreased rugosity, and the possibility of giving increased slope to the bed to give greater velocities.

(4) The following are typical cases:—

Assumption.—Loss by absorption in earthen and concrete lined channels eight and two cusecs per million square feet respectively; co-efficient of rugosity, .0223 and .015 for earthen and concrete lined channels. Value of one cusec mean discharge 2,000 rupees per annum, capital value of one cusec at 25 years' purchase. To construct a channel to carry 8,000 cusecs concrete lined, instead of an earthen channel of the same slope, is sound financially from the value of the water saved, on the above assumption, if the cost of lining is Rs. 48 per hundred square feet. To construct a lined channel to carry 2,770 cusecs in place of a unlined one, with a slope of one in 6,666, is similarly financially sound, if the cost of lining is Rs. 55 or Rs. 63, according to whether the slope is increased to one in 5,000 or one in 4,000.

(5) To give the cost of lining of canals in terms of acreage irrigated is difficult, as the assumptions would be so many. To save one cusec mean discharge involves interest charges of 2,000 rupees per annum, if the lining be done at the rates given above. At Rs. 30 per hundred square feet for lining, the interest charges would be from Rs. 1,500 to Rs. 1,000 per annum, as one cusec mean discharge per annum in a distributary may give anything from 300 to over 500 acres of crop (the amount of cotton in this would vary according to the canal in question) and this is well below the value of a cusec mean discharge in distributaries from water-rates alone.

(6) In carrying out improved methods of irrigation involving higher capital expenditure, it is very difficult to establish the financial soundness according to the existing Codo Rules, as there are so many indirect benefits, which are not permitted to be taken into consideration, but which nevertheless economically exist. The tendency is to consider the matter from too parochial a view and not on broad lines.

(7) Closures are practically impossible. A case of the lining of the Patiala Feeder of the Sirhind Canal has risen in the Sutlej Project; its capacity at the head has to be increased from 3,000 to 8,000 cusecs approximately and it has been found financially and executively more sound to build an entirely new lined canal alongside, and then silt up the old channel and sell the land. This is a bold procedure, but the proposal finally adopted. The lining of the Main Line of the Sirhind Canal will be made feasible after the construction of the Bhakra Reservoir. Closures will be possible, as during the closure period, the water, instead of being lost down the river, will be stored in the reservoir and utilised later, by running the canal full supply

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by adding the stored water to the normal river supply, which would otherwise be only half the capacity of the canal. By this means, the same quantity of water will be able to pass down the canal and yet two months or more closure will be possible. The lining will be of cement concrete slabs. With an efficient lining the difficulties from the waterlogging due to the canal would vanish. Waterlogging is almost entirely due to percolation from the main channels and but very slightly due to irrigation on the fields.

(8) The question of the expenditure that would be justified on lining, as preventing waterlogging, is one of those advantages for which no monetary value can be definitely fixed; it is not only the damage caused to land, but the economic loss due to the death and degeneration of the inhabitants of the affected tract. No one, so far as known, has enunciated the capital value to the state of a normal household. Even in the case of a cusec of water, no accepted estimate has been made of the value to the State of a cusec of water in a water-course. The water-rate is a very small portion of the value which accrues to the state, but this is a point, which is more often than not, left out of consideration. In the Sutlej Dam Project, the total saving in losses, owing to lining, when full supply is running, will be of the order of 1,500 cusecs. The amount saved in the two crops will be roughly proportional to the discharges run. It has been shown above that the expenditure is justified.

3361. (64) Suitability of water rates.—It has been shown earlier that water rates have no effect on the proportion of wheat to cotton; generally speaking, it may be said that canal water rates are such a small proportion of the costs of the production of the crop, that the cultivators give little consideration to water rates. When trouble has occurred over the raising of water-rates in the past, it has been at the incentive of political discontents. As an example, when the schedule for water-rates for sugarcane on the Upper Bari Doab Canal was to be changed in about 1906, the proposal was abandoned on grounds of political inexpediency.

(2) When the upper distributaries of the Sirhind Canal were converted from perennial into *Kharij* ones, the cultivators continued to grow sugarcane, getting water for half the year, and yet they continued to pay the full water-rate for the year of Rs. 7-8-0, which was raised to Rs. 12 per acre in 1904, and no complaint was made, shewing the little consideration given to the water-rate.

(3) The fair value of canal water-rate would be such, that in a tract where well irrigation is permissible, the cultivator would consider whether it were cheaper for him to work his well or take canal water. At present, on that basis of argument, the water rates are only 20 or 25 per cent. of what would be permissible.

(4) Witness is strongly of the opinion that higher rates should be charged and better service given. Irrigation could then be extended into famine stricken and precarious inhabited tracts, in preference to irrigating desert tracts, which have to be cultivated by people transplanted from their homes, simply on account of the question of the pitch of water-rates, making the latter alternative financially more remunerative. Surely the men would prefer to pay a fair rate for water and get it at their homes than have to go to a barren tract and get it at a nominal rate.

(5) Further, witness considers, the water-rates are too low for the following reason. The waters of the Punjab rivers belong to the Government, that is, to the people, as Government is supposed to be the representative of the interests of the people. Water is a marketable commodity; the inhabitants of some tracts are prohibited by physical conditions from being able to utilise the water; if the water is sold to inhabitants of physically favourably situated tracts at a nominal rate below the market value, the inhabitants of the other tracts are losing their share of the benefits, as they are beneficiaries of the Government, who represent their interests. The result is, for the administration of the Province, owing to the canal water-rates providing a smaller proportion of the revenue than they should, the remaining revenue has to be raised by some general taxation over the whole Province and falls on those who cannot benefit from irrigation; whereas if the water-rates were nearer the market value, there would be no need to raise extra taxation from both classes. Or inversely, if the same amount of taxation with higher water-rates was levied, there would be more money at the disposal of the community for improvements which are sorely needed.

3362. Summary.—(a) Witness is of the opinion that, in endeavouring to increase cotton cultivation, due caution should be taken to see that it is not done at the expense of wheat, an essential. More especially American cotton, which appears to effect the wheat area more than *deshi* cotton.

(b) There is no doubt that the Sirhind Canal, from a point of view of water available, offers a large scope for the development of cotton. In the upper portion of the Sirhind Canal tract, there are large areas in which the proximity of sub-soil water to natural surface offer the conditions said to be the most suitable for American cotton. If in addition to wheat, barley be included as a cereal equivalent to wheat, the Sirhind Canal comes far above 24:1 in the proportion of wheat to cotton. Yet on the Sirhind Canal the wheat water-rate is the highest in the Province.

(c) Witness is of opinion that there is a large scope for the utilization of the power of canal falls in the upper reaches of the Sirhind and other canals to work tube wells. The power units to be standardised for the province and the whole worked as an organization and not by the local canal officers.

(d) That the putting of an oil fuel produced in the Province on the market at a cheap rate would cause an enormous development of cultivation by pump irrigation.

(e) That in preference to increasing the capacities of existing canals, it would be preferable to spend capital on storage works, so as to work the existing channels more effectively. With an increase in the efficiency in distribution and use of water that may reasonably be expected, witness is of opinion that the capacities of the Doab Canals, where extensions are not possible, are generally sufficient, especially if lining work is undertaken.

(f) That the Sutlej Dam Project will give at least 1½ million acres of irrigated crops, a large portion of which will be in the Western Jumna Canal tract, that does the greatest proportion of cotton of any canal.

(g) There is great scope for the Agricultural Department to study the question of cotton cultivation on the Sirhind Canal and stimulate the cultivators by example. So far, the Sirhind Canal tract appears to have been left out in the cold by the Agricultural Department, perhaps partly because such a large portion of the area is in Native States. Since 1912 witness has never seen or heard of any action of the Agricultural Department in the tract. In the Faridkot State model farm, witness has seen the only American cotton on this canal. The land there is light and it appears that it can carry American cotton all right.

(h) Steps taken to stabilize the price of cotton would probably increase the area as the cultivators would feel there was not so much danger of not getting a normal profit.

(i) To encourage the growth of cotton, the utilising of power at canal falls (item c) for cotton ginning would stimulate the growth as it would make the handling of the produce locally more efficient.

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Mr. H. W. NICHOLSON.

[Continued.]

(j) That to have any useful effect the efforts of the various departments need far more co-ordination than exists at present, and a wider economic view should be taken in place of the narrow departmental view which so often prevails.

ANNEXURE I.

Statement showing proportion of cotton area to wheat on the canals in the Punjab.

Name of Canal	WHEAT.		COTTON.		Proportion. wheat to cotton.
	Acres.	Rate.	Acres.	Rate.	
Major Canals	2,500,000	Rs. A. P.	750,000	Rs. A. P. ...	3.3 to 1.
Minor Canals	320,000	.....	68,000	...	4.7 to 1.
Perennial Canals.					
Western Jumna Canal	200,000	4 0 0	180,000	4 0 0	1.1 to 1.
Upper Bari Doab Canal	250,000	3 12 6	170,000	2 12 5	1.5 to 1.
Lower Chenab Canal	980,000	4 4 0	200,000	4 4 0	4.9 to 1.
Lower Jhelum Canal	380,000	3 12 0	45,000	3 12 0	8.5 to 1.
Sirhind Canal (Native States)	150,300	} 5 4 0 {	25,000	} 4 0 0 {	5.8 to 1.
Sirhind Canal (British)	290,300		12,000		24.2 to 1.
Inundation Canals supplied by weir.					
Sidhnai Canal	90,000	3 5 0	34,000	3 5 0	2.7 to 1.
True Inundation Canals.					
Upper Sutlej Canal	54,000	1 0 0	28,000	1 8 0	1.9 to 1.
Indus Inundation	45,000	0 8 0	24,000	1 0 0	1.9 to 1.
Shahpur (Imperial)	16,000	2 8 0	5,000	2 8 0	3.2 to 1.
Chenab Inundation Canal	64,000	0 14 0	20,000	1 12 0	3.2 to 1.
Muzaffargarh Inundation Canal	145,000	0 12 0	35,000	1 8 0	4.1 to 1.
Lower Sutlej Canal	96,000	0 14 0	20,000	1 12 0	4.8 to 1.
Shahpur (Provincial)	5,000	2 8 0	1,000	2 8 0	5 to 1.
Ghaggar (Contribution)	500	2 8 0	100	2 8 0	5 to 1.
Ghaggar Inundation (Imperial)	2,500	2 8 0	Nil

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Mr. H. W. NICHOLSON.

[Continued.]

ANNEXURE II.

Statement showing the relation of proportion of cotton to wheat grown on perennial canals (five years average.)

Canal.	MEAN DISCHARGES.			MEAN AREA 5 YEARS.		Wheat Cotton.	PROPORTION.				REMARKS.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	Kharif.	Rabi.	Autho- rized supply.	Wheat.	Cotton.		Wheat Area.		Cotton Area.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
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Western Jumna Canal	3,319	2,623	6,130	200,000	180,000																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

NOTE.—In addition to wheat on the Sirhind Canal there is a large area of barley not included, which is far more in proportion than on any other canal.

† The Lower Jhelum Canal figure is low as the supply in the river in winter has been in excess of demand and irrigation therefore has suffered.

‡ Upper Bari Doab Canal figure is high as the duty on the Upper Bari Doab Canal is higher than on the Western Jumna Canal owing to greater intensity of irrigation, 55 per cent. instead of 30 per cent.

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Mr. H. W. NICHOLSON.

[Continued.]

Mr. H. W. NICHOLSON called and examined.

3363. (Mr. Ashon.) From a financial point of view, considering returns on capital cost of a canal only, the more intensive the cultivation the better the financial return. But from an economic point of view the larger the area over which the irrigation is spread the better.

3364. The Hissar District is the most liable to famine of any District in the province.

3365. There would be no advantage in enlarging the Sirhind canal to carry increased *khariif* supplies as an inspection of the diagrams submitted with my written evidence shows that the existing capacity is seldom fully utilized in the *khariif*. On the average of ten years, the mean supply utilized in the *khariif* is only 51 of the maximum. The people make all the money they want out of *rabi* irrigation and do not care about working in the hot season when their needs are already supplied.

3366. The effect of lining canals would be to increase the area cropped in proportion to the amount of water saved to that now utilized. By lining canals as proposed in the Sutlej Dam Project, absorption is reduced to the minimum possible and figures are given in my written evidence which show that it is financially sound. If existing canals were lined, their capacity would be in excess of what is required. It is therefore much more economical to line a canal when it is constructed than later, after it has been completed as a normal earthen channel, with a section in excess of what is required when lined. In the *khariif* season, lining would tell at the critical periods of supply which are at the beginning and end of the *khariif* season. On the Sirhind Canal, the most critical period is September and October, if there are no late rains, if there are late rains, then the critical period does not occur. As to whether the lining of canals is economically sound and paying, a great deal depends on the water rates you levy.

3367. I am a strong advocate of higher water rates. I submit two diagrams (Annexures I and II) shewing the water rates per acre and the price of wheat and cotton per maund for the Sirhind Canal for a forty-year period. They show that the water rate per acre has not increased to keep pace with the increased price of the produce. The pitch of the water rates does not appear to have any effect on the cultivators' preference for any particular crop. The cultivator frequently deliberately submits himself to a fine of double water rate for taking water in an unauthorized manner and is quite pleased to do so as the rates are so light.

3368. Canal water on the Sirhind Canal can be conserved by utilizing the sub-soil water by means of pumps. The upper reach of the Sirhind Canal provides an ideal condition for utilizing the power at the falls for working pumps. As regards the utilization of the power of canal falls, the difficulty in the past has been that it was tried and then worked by men who had no mechanical experience and the result was unsatisfactory and the scheme has therefore been condemned unjustly. The question has not really been taken up seriously in the past. One fortieth of the whole revenue of the Sirhind Canal is obtained from the country flour mills fixed up at many of the falls.

3369. (Mr. Roberts.) I do not say that cotton is an unsafe crop on the Sirhind Canal but what I do say is that the people do not go in for it. There is enormous scope for the development of cotton on the Sirhind Canal as the water is available but not being used. The preference of the cultivator for wheat is probably due to the fact that he finds cotton unreliable as compared with wheat for profits and because he has not to work in the hot weather to cultivate wheat. Cotton would be sown at the end of March or during April and thus the sowing of cotton clashes with the harvesting of wheat. There is no doubt that the sowing of cotton clashes with the harvesting of wheat. If it could be sown later, then it would not clash. The Agricultural Department has done nothing on the Sirhind Canal. I have been five years on the Canal. There is no doubt that there is scope for the development of cotton cultivation. Little can be done by arguing with the cultivators. So far as the canal is concerned, no changes are required to cause cotton cultivation to be developed. The first year of the war I tried to get the *zamindars* to put down cotton but they replied that they lost in the previous year as its price fell so low. I pointed out that owing to the war the price was bound to rise but they considered themselves wiser and did not sow much.

3370. (Mr. Wadia.) If a certainty of selling price could be guaranteed, it would be a great incentive to cotton cultivation. It could be arranged by some organization or large financial firm which could afford to balance one year's losses against another year's gains. In the early days of the Lower Jhelum Canal the firms contracted with the *zamindars* for their wheat at the time of sowing; they were thus certain of their price. This might be done in the case of cotton.

3371. (Mr. Henderson.) As regards the prospects of cotton on the extension of irrigation under the Sutlej Dam Project into Bikaner, there is excellent soil in the northern part of Bikaner. It would probably be much the same soil as in Sind.

3372. The Sutlej Dam Project is more or less of a protective nature as the Sirhind Canal was when built but the latter pays eleven per cent. The gross commanded area which will be opened up under the project is 3,300,000 acres out of which not less than forty per cent. would be irrigated annually.

3373. There is a very big scope for cotton. The only question is, is it desired to develop cotton at the expense of wheat? When ploughing for cotton is going on, wheat takes its last watering and cotton takes its last watering when wheat takes its first watering.

3374. The later the sowing of cotton is delayed, the more trouble there would be from the sandstorms in the lower reaches of the canal. It is one of the arguments against cotton that, if it is sown late, the small plants are cut to pieces by sandstorms. It will take some time for the sandstorms to be lessened by increased cultivation binding down the sand but there will undoubtedly be a slow and continuous effect in that direction produced by the extension of irrigation. When there is a low demand, distributaries can only be run with a low supply owing to water-courses being closed. That means that men who might want to grow cotton on land that is not commanded with a low supply in the distributary are precluded from cultivating it. I have discovered in the field this difficulty of low supply in the *khariif* making it impossible to irrigate lands which are irrigated without difficulty in full supply.

3375. I am strongly in favour of an extension of the work of the Agricultural Department especially in connexion with agricultural machinery.

Punjab.]

Mr. W. P. SANGSTER, C.I.E.

Mr. W. P. SANGSTER, C.I.E., Superintending Engineer, Lower Jhelum Circle.

EXAMINED AT LAHORE, JANUARY 8TH 1918.

Written statement.

VI.—IRRIGATION.

3376. (50) Experience.—I am a Superintending Engineer of the Irrigation Branch, Public Works Department, of 23 years service, out of which eleven years were on revenue work on running canals, 9½ years on purely construction work, and 2½ years on furlough.

3377. (51) Wheat versus cotton.—Cultivators most decidedly prefer wheat to cotton as an irrigated crop. The statement (Annexure I) attached points to the general popularity of wheat in all types of villages. Annexure II also shows that, in the Circle as a whole, the area sown with wheat is roughly four times that under cotton. The reasons for this preference are probably as follows:—

- (i) Wheat is much less liable than cotton to damage by insect pests.
- (ii) It is the staple food crop of the Punjab, and provides also good cattle food in the way of *bhusa*.
- (iii) The market is much more certain and stable than for cotton.
- (iv) Wheat is less troublesome and involves less labour in gathering. Such labour as is required extends over a short period, and is called for when the season is cool. From the custom of payment in kind, it is easy to obtain labour, and communities not amply provided with labour are less dependent upon outside assistance than in the case of cotton.

3378. (52) (a) Critical period in regard to water supply.—The period of greatest demand for water is in September and October. In October, the second watering is given to *toria* and the first watering to wheat. Also the final watering of American cotton arrives at a time when the demand for *toria* sowings in the event of an unfavourable monsoon is very keen. March is also a critical period when wheat is getting its final watering upon the timeliness of which the outturn depends. Since the extension to this canal of rotational closures during *rabi*, it has become more difficult than formerly to meet the demand during this critical period, which affects all canals alike, and occurs when the available supply in the river is still low.

(2) In the case of *deshi* cotton requiring its first watering in the latter part of April and in May, the demand for cotton would not be felt until after the critical period for wheat. But, in the case of American cotton, the two demands would assuredly coincide and greatly affect the area of such cotton that would be sown.

3379. (52) (b) Watering of cotton.—Failing assistance by rain, American cotton sown in March is given a five-inch depth of water for sowing, a four-inch watering in May, and thereafter four waterings of three inches each at approximately equal intervals, the last being given in October. *Deshi* cotton sown in April or May is given a five-inch watering at sowing, a four-inch watering about one month later, and, thereafter, three waterings of three inches each at about equal intervals. Apart from rain, American cotton requires a total depth of about 21 inches, and *deshi* about three inches less.

3380. (52) (c) Statistics.—The average monthly discharges and the average monthly areas of each crop irrigated by the Northern Branch, Lower Jhelum Canal (excluding the Sulki Branch), are given in Annexure II attached. Those for channels on the Southern Branch are given in Annexures III and IV.

(2) The average daily supply on the Northern Branch during each month may be expressed as a percentage of the maximum carrying capacity, viz., 1,400 cusecs. These percentages are as below:—

Kharif.					Rabi.				
April	.	.	.	66	October	.	.	.	93
May	.	.	.	80	November	.	.	.	85
June	.	.	.	66	December	.	.	.	74
July	.	.	.	76	January	.	.	.	47
August	.	.	.	63	February	.	.	.	76
September	.	.	.	92	March	.	.	.	76
Average for kharif					Average for rabi				
					= 75 Per cent.				
					Average for the whole year				
					= 74 Per cent. of maximum capacity.				

3381. (53) (a) Possibility of expansion of area under cotton by enlargement of canals.—During the *kharif*, the supply in the rivers is sufficient for a large expansion of the areas irrigated. No enlargement of the Lower Jhelum Canal is necessary at present, as the average supply required in the *kharif* is only about 73 per cent. of the maximum carrying capacity of the canal. Thus the capacity of the Lower Jhelum Canal has not yet been fully utilized in the *kharif*. There is thus room for an expansion of cotton without enlarging the canal. But if there was a large expansion of cotton cultivation, there would probably be a decrease in the area of wheat cultivation as the cultivators, having expended more energy and land on cotton, would have so much the less energy and land for wheat.

(2) At present the proportion of *kharif* to *rabi* on the Lower Jhelum Canal as allowed and calculated for is 1 to 2. If it ever became necessary to restrict the *rabi* supply to the Lower Jhelum Canal so as to utilize it elsewhere (on the Lower Bari Doab Canal, for instance), it would be necessary to alter the proportion of *kharif* to *rabi* to 1 to 1. To do this, it would be necessary to enlarge the canal by fifty per cent. This was recently estimated to cost 35 lakhs of rupees. But the cost of enlarging would then be properly debitable to the Lower Bari Doab Canal. This canal itself could not afford to pay the cost of enlarging as it would gain nothing. In fact it would be a dead loss financially for the average *rabi* crop rate on the Lower Jhelum Canal is greater than the average *kharif* crop rate. [Vide also paragraph 3389 (8)].

3382. (54) (a) Improvement in duty of water by remodelling of outlets.—On the Lower Jhelum Canal, the distribution of the supply between the upper and lower outlets on the distributaries is already equalised and there is practically no room for improvements of the duty of water. It has already been decided to instal Kennedy gauge outlets on all the distributaries of this canal.

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[Continued.]

3383. (55) Fluctuations in river supplies and their effects.—The rivers increase gradually in the spring and decrease gradually in the autumn. The attached rise and fall diagram (Annexure V)* illustrates this.

3384. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—It is only on inundation canals that cotton is sown on well waterings until canal water is available, and that it is matured after the supply of canal water has ceased. In the whole of the tract irrigated by the Shahpur inundation canals, a combination of irrigation from wells and canals would be quite feasible, as wells exist over the whole tract. In *bar* (upland) land, wells are deficient in number, brackish and too deep for cheapness in working. The *khadir* (low land) lands are much better off in all these respects; wells are more numerous with sweeter water and less depth. But this land is generally owned by the original *jangli* inhabitants who are not likely to cultivate cotton at the expense of their cattle or in place of less troublesome and laborious crops such as wheat and fodder crops.

3385. (56) (d) and (e) Construction of weirs versus construction of wells.—The only scope for improvement on this canal so as to obviate the use of wells would be in completing the Shahpur Branch of this canal and so do away with all the inundation canals in the Shahpur district. The tract irrigated by these inundation canals would then get much earlier and better supplies in spring and much later and better supplies in autumn. No help from wells would then be required for cotton. American cotton could probably then be introduced with great success in this tract. At present it grows practically only *deshi* cotton. Unfortunately the owners of the private inundation canals in the Shahpur district have strenuously opposed the supersession of their own canals by irrigation from the proposed Shahpur Branch. If they could be induced to agree to the Shahpur Branch being completed and to its taking up the irrigation of the tracts now watered by their private canals, there would certainly be scope for a large increase of American cotton in this tract. This Shahpur Branch is practically already completed, but cannot be brought into use owing to the attitude of the owners of these few private canals. To complete the Shahpur Branch and to irrigate from it the whole tract of the inundation canals would cost a comparatively small sum.

3386. (58) Cropping and causes affecting it.—Annexure I gives a rough estimate of the average area of each crop grown on a holding of 100 acres. The figures in italics give the percentages in terms of the holding or cultivable land; the other figures below these exhibit the areas sown as percentages of the total area actually cultivated in the whole year.

(2) Four groups are given. The first group contains three large villages owned by *janglis*. The land is good upland and the owners are more affluent and enterprising than the inhabitants of group IV villages which lie in *khadir* land where the soil is poorer and the inhabitants are more conservative. Group II contains five typical villages where the land is held on horse breeding conditions. Group III contains four villages allotted to civil grantees who are, as in the horse breeding *chaks*, direct tenants of Government but are free from the obligations imposed upon horse breeding tenants.

(3) It is very difficult to say how the areas of Annexure I would be affected by the water supply, the necessity for growing a fodder crop, and of preserving suitable rotations of crops, for the reason that conditions have in any particular village remained appreciably constant. As regards water supply, however, a change in conditions arose with the extension, during *rabi* 1916-17, of the principle of rotational closures. It was to be expected that the effect of this change would be to reduce the area of *rabi* crop and increase that of *kharij*. No such diminution of the *rabi* area was, as a matter of fact observable last *rabi*; but this may be due to the fact that cultivators were slow to realise the change, which did not come into effect until the greater part of the *rabi* crops had been sown. Nor has there been any appreciable increase in *kharij* sowings, and the demand during *kharij* was invariably much less than the maximum capacity of channels. The effects of the other two factors cannot be stated, as the conditions in any particular case have been invariable.

3387. (64) Suitability of water rates.—The water rates charged have no appreciable effect on the cultivator's preference for a particular crop. The chief crops sown are wheat, *toria* and cotton and the rates in force are light in proportion to the profits derived. Near large towns, where there is a ready market, cultivators do not consider the rates, but in the jungle areas they perhaps do, to some extent. The high rates on sugarcane, *viz.*, Rs. 10 per acre certainly keeps down the amount of sugarcane grown.

(2) Some minor changes in the water rates are required to prevent fraud, and to remedy certain defects whereby *patwaris* and cultivators are enabled to take advantage of existing rules. An instance may be given in the case of melons and cotton sown together: by the rules in force only melons are charged, although cotton is given water long after the melons have been gathered. This rule would appear to favour cotton sowings unduly. Similar instances might be quoted.

(3) It is not thought, however, that such minor changes as are indicated as desirable, would, if brought into force, have any appreciable effect upon the popularity or otherwise of any particular crop.

3388. (49) Effect of tenure of land.—On the Lower Jhelum Canal there are broadly speaking only two kinds of tenure on which lands are held, *viz.* :—

(i) In new villages, *i.e.*, in colony land, where the cultivator is a tenant of Government.

(ii) In old villages, where land is owned by the original *jangli* inhabitants.

(2) In (i), in the majority of cases, land is held under horse-breeding conditions, and the primary duty of the cultivator is to provide for his stock. In a few cases, however, the cultivators are civil grantees who are under no such restrictions as to the choice of crops. In Annexure I, the second set of figures shows the average performance of five typical horse-breeding *chaks*; while the third set gives the performance of four civil grantee *chaks*. As regards cotton sowings it will be noticed that the percentage sown is greater in the case of the former than in the latter *chaks*. This may be held to indicate that the land granted under horse-breeding conditions is allotted on a generous scale, which allows of the cultivation of profitable crops not directly connected with horse-breeding. The figures for *toria* and wheat bear out this conclusion. The higher figure for cotton in the case of horse-breeding colonists may be attributed to the fact that they are, generally speaking, better cultivators and better off than the civil grantees, who are not usually of the *zamindari* classes.

(3) In old villages, the *jangli* inhabitants invariably keep large herds of cattle, and their chief concern is to provide fodder for these. They are not generally speaking affluent, nor are they good cultivators. They are not so well provided with *muzarias* or tenants as the colony villages and for this reason, and from a certain characteristic love of ease and lack of enterprise, they are disinclined to grow crops, such as cotton,

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[Continued.]

which require attention and labour during the hot weather. It is thought that cotton is not likely to become a popular crop among them for the above reasons. In Annexure I, the first and last sets of figures show the performance of two groups of *jangli* villages. In the first group, the land is much better and the people more affluent and enterprising than in the last group.

3389. (59-63) Lining of canals.—I have had no experience in regard to the lining of canals. I consider that water proofing of canals is impracticable on the large scale essential to its effectiveness. Experiments carried out on the Upper Bari Doab Canal about 33 years ago showed that the supply entering a canal at its head could be accounted for as follows :—

	Per cent.
Loss in the main line and branches	20
Loss in the main line distributaries	6
Loss in the watercourses	21
Loss arising from waste on the fields	25
Balance actually beneficial to crops	28

Therefore, even if we made all canals, branches and distributaries water-tight there would still be a very considerable loss in watercourses and in wasteful irrigation in the fields. In Egypt, all the canals are practically water-tight because the Nile carries almost no sand, but only a fine mud which forms an impervious natural puddle lining. Yet water-logging due to bad distribution and wasteful irrigation had become so serious that vast sums of money are being spent on drainage and pumping schemes. Thus all water-logging is not due entirely to percolation from canals. Even though we made all our canals, branches and distributaries water-tight, we would probably still have to resort to drainage schemes to solve seepage problems and the rise in the subsoil water table, as they have had to do in Egypt. Therefore I do not think any expenditure on lining canals would be justified *only* on the grounds of solving seepage problems and the rise in the subsoil water table.

(2) In the Punjab, the lining of canals would not improve the supply in the summer months as there are always more than ample supplies in the rivers in those months. It would, of course, improve the supply in the winter months when the river supplies are low. But we have not yet reached the stage at which it is necessary to line canals to improve the winter supplies. The winter supply is on the average at present sufficient for the existing canals. In exceptionally dry years, there will be a shortage to some extent now that the Triple Canals are in operation. But the Woolar Lake in Kashmir is to be made into a storage reservoir by means of a barrage at Soper, so that the winter supply will be supplemented.

(3) It is a practicable scheme to line new canals when they are being constructed and it has even been proposed to line some of the new branches in the project under preparation in the Sirhind Circle, as on making comparative estimates, it was found that from Rs. 40 to Rs. 50 per 100 square feet could be spent on lining and that it would still pay because very much smaller channels would be required which would mean less land, less excavation, less masonry, etc.

(4) The chief reason why it is so difficult and so costly to line existing canals is that it is impossible to have long enough closures to carry out the work. Work done hurriedly in a closure generally costs double or treble the amount it would cost if done at leisure. On the Lower Chenab Canal, each cultivator in the winter months receives water only once a month. If the canal were closed for a month, the last man in a *chak* would not receive water for two months and, in the absence of rain, his crop might be ruined.

(5) It may be of interest to mention that on the Lower Chenab Canal the sums already sanctioned for water proofing channels are—

	Rs.
(a) 1 mile of main line at Muradian	1,73,000
(b) 2 miles of main line below Sagar	2,00,000
(c) 6 miles of Jhang Branch, Upper	4,00,000
(d) 7 miles of Kot Nikka Branch	2,54,000
TOTAL	10,33,000

The cost of lining varies from about Rs. 20 per hundred square feet for clay puddle to as much as Rs. 40 to Rs. 50 per hundred square feet Portland Cement linings.

(6) The average annually irrigated area for the last five years on the Lower Jhelum Canal was 817,663 acres. The total cost of the Lower Jhelum Canal (direct charges) up to end of 1916-17 was Rs. 1,55,43,447. The cost per acre was, therefore $\frac{1,55,43,447}{817,663} = \text{Rs. } 19$. The cost of lining varies from Rs. 20 per 100 square feet to from Rs. 40 to Rs. 50 per 100 square feet. The total number of square feet in the beds and side slope of all the channels on the Lower Jhelum Canal is approximately as follows :—

	Square feet.
Main Line	321,83,200
Branches	41,582,964
Distributaries	53,846,865
TOTAL	1,27,613,029

Taking Rs. 30 per 100 square feet as the average cost of lining, the total cost would be $\frac{\text{Rs. } 12,76,13,029 \times 30}{100} = \text{Rs. } 3,82,83,909$.

The cost per acre of annual irrigation would be $\frac{38,283,909}{817,663} = \text{Rs. } 46.8$ per acre.

(7) The enlargement of a canal could be done more easily during short closures than the lining. The work of enlarging does not involve the elaborate preparations necessary for the work of lining. A considerable amount of the work of enlarging can generally be done by means of temporary coffer dams and bunds whereas lining could not be so done.

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(8) If the size of the Lower Jhelum Canal were increased and the irrigated area under cotton thereby increased, there would be no addition to gross revenue, as the water-rate for cotton is the same for wheat, viz., Rs. 3-12-0. It may be mentioned that on the Lower Jhelum Canal the average *rabi* water-rate assessed for the last ten years was, with one exception, greater than that of *kharij*. (See figures below)—

Year.	<i>Kharij</i> .	<i>Rabi</i> .	Year.	<i>Kharij</i> .	<i>Rabi</i> .
	Rs.	Rs.		Rs.	Rs.
1906-07 . . .	2-04	3-07	1911-12 . . .	3-30	3-45
1907-08 . . .	3-18	3-04	1912-13 . . .	3-21	3-46
1908-09 . . .	3-30	3-51	1913-14 . . .	3-35	3-47
1909-10 . . .	3-35	3-58	1914-15 . . .	3-37	3-47
1910-11 . . .	3-38	3-56	1915-16 . . .	3-10	3-45

(9) But as already stated, I do not consider that we have reached the stage or are likely to reach if for some time, at which it is necessary to line existing canals. In certain branches and small canals where lining is feasible at a reasonable cost and where percolation losses are known to be great owing to a possibly greater porosity of soil and to be causing deterioration of neighbouring lands, it would probably be advisable to make an impervious lining and experiments are being carried out at present on the Sirhind Canal to find out which is the most practical and effective lining to use. The progress of these experiments has, however, been hampered by the war.

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[Continued.]

ANNEXURE I.

SARGODHA DIVISION, LOWER JHELUM CANAL.

Statement showing a rough estimate of the average area of each crop grown on a holding of 100 acres in old and colony villages of the Shahpur and Jhang Districts separately.

Serial No.	Name of village.	Average area of each holding.	Average area of one square.	Total area cultivated during the year.	Sugar-cane.	Rice.	Cotton.	Toria.	Wheat.	Fodder.	Miscellaneous.	REMARKS.
Group I .	1 Lak	1 square .	Acres. 27-75	Acres. 23-00	Nil.	Nil.	1-33	3-34	11-00	4-33	3-00	Old villages, Shahpur District.
	2 Mari	1 square .	27-75	28-00	...	"	0-66	2-67	14-00	6-34	4-33	
	3 Sakesar	1 square .	27-75	27-66	2-33	"	1-66	2-34	13-33	3-00	5-00	
	TOTAL	3 squares .	82-25	78-66	2-33	Nil.	3-65	8-35	38-33	83-67	82-33	
	Average	1 square .	27-75	26-22	0-78	"	1-22	2-78	12-77	4-56	4-11	
Average percentage of culturable area			...	95-96	2-85	Nil.	4-47	10-17	16-73	16-69	15-05	Colony villages on horse-breeding conditions, Shahpur District.
Average percentage of cultivated area			...	100-00	2-97	"	4-66	10-58	48-74	17-38	15-67	
Group II .	4 Chak 18 N. B.	1 square .	27-75	29-00	1-00	"	2-50	7-50	8-50	5-50	4-00	
	5 Chak 19 N. B.	1 square .	27-75	23-00	0-50	"	2-50	4-50	8-00	4-00	3-30	
	6 Chak 54 N. B.	1 square .	27-75	28-00	Nil.	"	3-00	3-50	11-50	6-00	4-00	
	7 Chak 55 N. B.	1 square .	27-75	23-50	"	"	Nil.	3-50	11-00	6-00	3-00	
	8 Chak 56 N. B.	1 square .	27-75	24-50	"	"	3-00	5-50	8-00	4-50	3-50	
	TOTAL	5 squares .	138-75	128-00	1-50	Nil.	11-00	24-50	47-00	26-00	18-00	
	Average	1 square .	27-75	25-00	0-30	Nil.	2-20	4-90	9-40	5-20	3-60	
	Average percentage of culturable area		...	93-70	1-10	Nil.	8-06	17-93	34-41	19-03	13-17	
Average percentage of cultivated area			...	100-00	1-17	"	8-60	19-14	36-71	20-32	14-06	

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[Continued.]

Sl. No.	Village	Area	27-75	29-00	3-00	1-00	2-00	7-00	6-00	8-00	2-00
9	Chak 78 N. B.	1 square	27-75	29-00	3-00	1-00	2-00	7-00	6-00	8-00	2-00
10	Chak 91 N. B.	1 square	27-75	32-00	1-00	Nil.	2-00	6-00	12-00	4-00	7-00
11	Chak 127 N. B.	1 square	27-75	31-00	Nil.	"	1-00	8-00	16-00	3-00	6-00
12	Chak 126 N. B.	1 square	27-75	32-00	"	"	Nil.	8-00	8-00	4-00	12-00
Total		4 squares	111-00	127-00	4-00	1-00	5-00	20-00	42-00	19-00	27-00
Average		1 square	27-75	31-75	1-00	0-25	1-25	7-25	10-50	4-75	6-75
Average percentage of culturable area			...	116-20	3-66	6-91	1-57	26-50	35-13	17-32	24-71
Average percentage of cultivated area			...	100-00	3-15	0-78	3-94	22-81	33-10	14-06	21-26
Total		4 squares	111-00	77-00	Nil.	Nil.	2-00	5-00	51-00	11-00	8-00
Average		1 square	27-75	19-25	Nil.	Nil.	0-50	1-25	12-75	2-75	2-00
Average percentage of culturable area			...	70-15	Nil.	Nil.	1-83	1-58	46-66	10-06	7-32
Average percentage of cultivated area			...	100-00	"	...	2-60	6-60	66-24	14-28	10-33

Colony villages, Civil
Grantees, Shahpur
District.

Old villages, Jhang Dis-
trict.

Group III

Group IV

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[Continued.]

ANNEXURE II.

SARGODHA DIVISION. LOWER JHELUM CANAL.

Statement showing the average monthly area, irrigated by the Northern Branch, Lower Jhelum Canal (excluding the Sulki Branch), during the last three years (1914-15 to 1916-17) with the averages of monthly discharges for the same period (April 1914 to March 1917).

Name of channel.	Name of month.	KHARIF.						RABI.						Total area irrigated.	Average monthly discharges.	REMARKS.			
		Sugar-cane.	Rice.	Cotton.	Maize.	Chart and Juar.	Palawan.	Miscellaneous.	Sugar-cane.	Wheat.	Barley.	Toria and Barshin.	Turnips.				Senh.	Gram.	Miscellaneous.
Northern Branch, Lower Jhelum	April	1,413	..	11,096	..	1,257	546	6,918	Acres. 21,230	Cusecs. 27,718	The figures of area irrigated and discharges given are for the last three years (1914-15 to 1916-17) i.e., the monthly average of the figures relating to <i>kharif</i> , 1914, <i>rabt</i> , 1914-15, <i>kharif</i> , 1915, 1915-16, <i>kharif</i> , 1916 and <i>rabt</i> , 1916-17.
	May	524	0	11,399	102	2,671	521	5,164	..	..	..	..	..	..	..	..	29,387	34,561
	June	43	133	3,006	80	3,425	1,129	4,532	..	..	..	..	..	..	..	..	12,951	27,670
	July	..	213	35	214	5,522	1,720	6,325	..	..	..	..	..	..	..	..	14,029	32,849
	August	..	94	51	1,780	10,836	591	11,184	..	..	..	..	..	..	..	..	24,542	27,265
	September	..	2	0	240	1,700	52	3,331	..	..	..	..	..	..	..	..	5,487	38,453
	October	..	..	..	..	..	..	..	1,980	5,402	121	21,271	11,253	187	1,598	22,380	62,262	40,173
	November	..	..	..	..	..	..	..	..	20,311	864	1,102	1,016	632	966	0,563	43,454	35,776
	December	..	..	..	..	..	..	..	..	55,219	1,930	631	312	1,200	731	8,709	68,852	31,094
	January	..	..	..	..	..	..	..	..	11,070	534	..	9	936	235	3,006	16,673	20,243
Canal (excluding the Sulki Branch)	February	..	..	..	..	..	..	..	..	634	13	..	..	686	235	1,930	3,503	29,888
	March	..	..	..	..	..	..	..	..	56	6	..	..	473	9	457	1,601	33,106
	TOTAL	1,980	448	26,106	2,528	25,411	4,556	37,504	1,980*	1,01,092	3,473	23,009	12,566	4,168	3,764	46,969	2,94,316	3,70,769	
Percentages of Total.		0.7	0.2	8.9	0.9	8.6	1.5	12.7	..	34.6	1.2	7.8	4.3	1.4	1.3	10.0	100.0	..	

*The area of sugar-cane irrigated under rabi is not included in the total for the crop. The maximum capacity of the Northern Branch (excluding Sulki Branch) is 1,490 cusecs.

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[Continued.]

ANNEXURE III.

KIRANA DIVISION, LOWER JHELUM CANAL.

Statement showing average monthly area of each crop under the Channels (average for the last three years taken) 1914-15 to 1916-17.

Name of month.	Khadir Feeder.										Kirana Distributary.										Italian Distributary.										Bacha Distributary.										Malay Distributary.									
	Southern Feeder.																																																	
	Sugar-cane.	Rice.	Cotton.	Maize.	Chart and Juar.	Miscellaneous.	Sugar-cane.	Rice.	Cotton.	Maize.	Chart and Juar.	Miscellaneous.	Sugar-cane.	Rice.	Cotton.	Maize.	Chart and Juar.	Miscellaneous.	Sugar-cane.	Rice.	Cotton.	Maize.	Chart and Juar.	Miscellaneous.	Sugar-cane.	Rice.	Cotton.	Maize.	Chart and Juar.	Miscellaneous.	Sugar-cane.	Rice.	Cotton.	Maize.	Chart and Juar.	Miscellaneous.														
April.	322	..	3,271	..	256	2,004	141	..	2,150	..	210	1,242	745	..	7,035	5	727	2,011	292	..	2,024	..	224	1,171	15,132	05	..	47	241	24	..	189	..	32	163															
May	209	..	5,243	27	1,230	1,848	111	..	2,231	2	412	718	401	1	5,235	13	1,170	2,004	039	..	3,877	07	1,206	2,017	14	..	200	4	61	108	31	..	850	1	118	100														
June	39	..	827	40	1,260	1,400	10	0	1,080	51	855	723	3	1	759	24	1,112	1,383	13	..	720	78	792	1,042	..	..	24	15	102	113	..	7	8	93	38													
July	..	21	3	180	1,285	2,201	..	200	21	104	1,453	601	..	56	..	222	1,720	3,104	8	22	104	203	1,372	2,944	..	4	1	13	50	137	..	8	4	07	180															
August	..	20	..	569	1,521	2,165	..	147	3	1,026	2,351	945	..	31	1	2,099	3,030	5,379	..	95	1	2,117	1,402	2,641	..	27	..	77	00	151	1	85	78	113														
September.	..	9	..	321	015	1,390	..	12	1	684	1,097	1,066	..	1	1	109	329	398	..	..	..	890	559	1,005	..	..	..	94	110	295	..	..	32	15	180							

Rabi.

Name of month.	Khadir Feeder.										Kirana Distributary.										Italian Distributary.										Bacha Distributary.										Malay Distributary.																								
	Southern Feeder.																																																																
	Wheat.	Barley.	Toria and sarshat.	Turnips.	Senjl.	Gram.	Miscellaneous.	Wheat.	Barley.	Toria and sarshat.	Turnips.	Senjl.	Gram.	Miscellaneous.	Wheat.	Barley.	Toria and sarshat.	Turnips.	Senjl.	Gram.	Miscellaneous.	Wheat.	Barley.	Toria and sarshat.	Turnips.	Senjl.	Gram.	Miscellaneous.	Wheat.	Barley.	Toria and sarshat.	Turnips.	Senjl.	Gram.	Miscellaneous.	Wheat.	Barley.	Toria and sarshat.	Turnips.	Senjl.	Gram.	Miscellaneous.																							
October	3,026	27	0,080	3,845	30,105	3,520	..	719	16,578	2,765	3	05	2,102	3,475	153	13,004	2,839	137	948	0,004	3,500	40	1,056	..	159	037	4,550	300	11	676	169	3	0	238	250	1	101	132	3	3	304																								
November.	12,774	408	1,201	527	105	02	1,017	8,088	209	139	579	110	39	1,345	10,003	554	555	134	815	544	4,145	7,023	100	1,830	..	390	189	2,439	956	35	177	..	53	9	89	980	2	107	0	..	34	173																							
December	10,383	007	140	80	061	165	2,009	13,144	46	502	125	53	953	71	19,747	041	107	2	1,049	439	2,825	25,071	613	3,128	..	1,253	779	2,160	1,723	04	..	101	5	83	1,080	42	..	31	1	52																									
January	0,450	217	58	22	521	8	3,911	8,352	108	10	31	301	15	5,700	8,320	200	13	..	2,384	412	1,017	10,009	253	316	..	589	34	1,107	442	4	..	07	..	44	122	1	..	10	..	5																									
February	255	45	239	2	478	1,077	47	221	4	036	145	452	44	358	541	11	5	..	252	0	397	43	1	..	31	..	21	23	..	29																										
March	110	13	108	2	403	548	8	209	10	259	119	6	1	..	129	15	311	20	37	1	12	18	1	..	2	..	24																									

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MR. W. P. SANDSTER, C.I.E.

[Continued.]

ANNEXURE IV.

LOWER JHELUM CANAL, KIRANA DIVISION.

Statement showing maximum carrying capacity and average discharge of the channels, month by month for three years (1914-15 to 1916-17).

Serial No.	Name of channel.	Authorised Discharge.	April.	May	June.	July.	August.	September.	October.	November.	December.	January.	February.	March.
1	Southern Feeder	300	300	257	304	238	249	361	387	367	361	291	275	269
2	Khadir Feeder	350	268	211	216	206	104	245	317	249	292	235	249	254
3	Bucha Distributary	34	30	25	29	2	19	35	39	35	34	31	20	28
4	Malay Distributary	20	19	14	17	20	16	20	23	25	22	19	18	16
5	Kirana Distributary	457	350	293	303	317	261	349	375	426	383	394	328	316
6	Lalian Distributary	380	280	298	315	308	274	350	370	345	336	267	305	276

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Mr. W. P. SANGSTER, C.I.E.

[Continued.]

Mr. W. P. SANGSTER, C.I.E., called and examined.

3390. (Mr. Ashton.) At the beginning of April, the supply of water in the Lower Jhelum Canal is sometimes short. Towards the end of April, there is generally a very good supply. It varies in different years. In some years, the show water comes down sooner than in others. In some years, when the river has come down early, the demand for water for *rabi* slackens at the end of April. During March, there is a keen demand for water for wheat. After the end of March, there is not so much demand for watering wheat but various other crops begin to demand water in April. I should say that there is ample water supply available in April to allow of a large increase of area under cotton, especially towards the end of April. The harvesting of wheat comes on about the end of April. Labour is very scarce and the people are hard up for labour at the time of wheat harvesting. The price of labour goes up enormously because of the shortage. There is not enough labour to go round. There is an ample supply of water available for the canal practically up to the end of October. In some very dry years, the river begins to drop towards the end of October but, in most years, there is an ample supply right up to the end of the month. There is room for expansion without enlarging the canal. We could, on the Lower Jhelum Canal, run a larger supply all through the *kharij* than we do at present but there is no demand for it. The demand is not up to the available maximum which the canal can carry. We could not carry more than a couple of hundred cusecs more than the present authorised full supply. To make any appreciable increase in the authorised full supply without running great risks would probably mean remodelling the whole canal. We are remodelling the canal and the remodelling is expected to cost approximately twenty five lakhs, including the remodelling of the head works. The enlargement of the canal by fifty per cent would cost forty lakhs, i.e., the extra cost would be fifteen lakhs. I do not think that by enlarging the canal we should get sufficient increase in the irrigated area to compensate for the extra expenditure. I do not see how we would get any increase in revenue by enlarging the canal, because if we increased the *kharij* area, we should probably decrease the *rabi*: the annual irrigation probably would not increase and consequently the annual revenue would not increase.

3391. We are not irrigating all our culturable land annually. We are working up to 75 per cent. in the *bar* land and up to an average of 50 per cent. in the *khadir* land, i.e., 75 per cent. in crown waste land in the *khadir* and 40 per cent. in old village land in the *khadir*. The *bar* lands are high lying lands and the *khadir* lands are the low lying lands near the rivers. I consider that there would not be any harm in increasing the intensity of irrigation up to cent per cent. in the *bar* land and up to 75 to 80 per cent. in the *khadir* land, provided we had a very efficient system of drainage. That would be necessary both for the *bar* and *khadir* lands. I think if there were sufficient properly graded drains in the *khadir* lands to permit of efficient surface drainage, they would prevent any bad waterlogging. The cost of the drains would have to be recovered by an increase in the water rates. I do not think that we would get that increase of intensity of irrigation under present conditions, because the people on the Lower Jhelum Canal are not very enterprising. They seem to be content with existing circumstances, and do not seem to have any ambition to increase their cultivated area especially in the villages in which there are *janglis*. There are a good many of such villages on the Lower Jhelum Canal. The *janglis* are very lazy and are content to make a bare living off their land. They are mainly in the old village land in the *khadir*. Some of them have got grants of land in the *bar* land but they are no more enterprising than the others.

3392. Now that the five canals are working, I do not think there will be any reduction in the *rabi* area on the Lower Jhelum Canal. This is only the second year in which the five canals have been worked and there were ample supplies of water this year in *rabi*. Last year was a very tight year and yet the *kharij* area did not increase as we expected it to do. There have been ample *rabi* supplies this year, as in former years, and so the people have come to the conclusion that the Triple Canals are not going to make much difference to their supplies in winter and so they are intent on putting in as much *rabi* as possible. The Woollar Lake scheme, if it is carried out, will improve *rabi* supplies, especially in dry years such as last year. In a year like this, we should not, of course, require the Woollar Lake water to supplement supplies. I consider that there would be water for a considerable increase of cotton without any diminution of the *rabi* area. It would probably mean an increase in the percentage of annual irrigation but I do not think there would be any harm in that.

3393. There are at present no bad waterlogged tracts on the Lower Jhelum Canal in which pumping might be substituted for canal water. It would be feasible to have pumping all over the *khadir* lands but it would be much more expensive than the present system of inundation canals supplemented by the ordinary wells which are worked by Persian wheels. There are no oil pumps or tube wells on the Lower Jhelum Canal nor on the inundation canals. There is practically no area waterlogged by seepage on the Lower Jhelum Canal.

3394. The inundation canals which take off from the Jhelum river are the Shahpur Inundation Canals. There was a scheme for linking up all these inundation canals with the Lower Jhelum Canal; but it has not been completed because there was some difficulty in coming to terms with the local owners of the private canals.

3395. I do not think the waterproof lining of canals an economic proposition under present conditions. I do not think it is necessary at present on the Lower Jhelum Canal where there are no bad reaches in which there is any excessive percolation of water.

3396. I do not expect to get any increase in irrigation by putting in Kennedy gauge outlets. We hope to improve the efficiency somewhat, that is to say, the efficiency of the different distributaries, so that by letting in the designed full supply at the head of the distributary we shall make sure of the proper amount of water reaching the tail.

3397. If the price of cotton increases to any extent, the cultivators might be induced to substitute cotton for wheat. The area under cotton is already extending considerably every year, chiefly due to the good prices that they are getting for cotton. Wheat has not been reduced; although the area under cotton has been increased. They are taking a little more interest in the *kharij* perhaps, or else are substituting cotton for other crops. I do not think that there has been much difference in the amount of water used.

3398. If the intensity were increased, it would probably bring in more revenue. There would be no objection to increasing the intensity provided a considerable sum of money was spent on a very efficient drainage. It might pay in the long run, but it would take some years. What would happen probably would be that the percentage of profit on the canal would drop considerably for a number of years but would then gradually rise to what it was before. In the end it might be more than at present, but that would probably take a good many years.

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[Continued.]

3399. I think that, in the inundation tracts, American cotton could be introduced with success. I think it would be a good scheme to link up the inundation canals with the Lower Jhelum Canal because we have already a branch in existence which would only require comparatively a small sum of money to complete. The people would be more likely to increase their cotton area if they got flow irrigation, instead of having to supplement from wells. Wells are costly things to work. I think personally it is feasible to link up the Government canals on the Shahpur branch and for the present to leave the private canals to irrigate as they do at present. The private canal owners would gradually be induced to come to terms. When they saw the Government inundation canals getting good supplies of water in the spring and in the autumn, they would probably very soon come to ask for a similar supply from the Shahpur branch and would take the water on our terms. The present system is very inefficient. Even on the Government inundation canals, we spend a large sum of money every year in making new heads, and on silt clearing, clearing reaches in the river, diversion-bunds and so on. It would be a very simple matter to link the inundation canals up with the Shahpur branch and save all that expense, worry, and trouble. Another great advantage would be that we should have much more control over the water. At present we have very little control over the water in these inundation canals because they have no proper head regulators. In times of river floods, they let down more water than is desirable and in times of heavy rain they cannot be closed so that, at such times, there are floods both from rain and from the river. That tends to waterlog the country. If the canals were linked up with the Shahpur branch, we should have absolute control over the water and could simply send it down when it was required by the crops and could close the canals at a moment's notice when rain fell. Apart from the question of irrigation, it would improve the condition of the country and would be an advantage to the welfare of the people themselves. The question of leaving out the private canals and simply linking up the Government canals, has not been raised at present, but I intend to work out a scheme to see what it would cost to link up the Government canals with the Shahpur branch and to provide crossings on the private canals. This, of course, is only in the air at present, and may not be feasible. I have not referred it to Government. There may be political objections to it. From an engineering point of view, it is quite feasible at a comparatively small cost and in my opinion it is desirable too, apart from political questions. There may be insuperable political objections to it. I could not say exactly how much has been spent on the Shahpur branch. I should think it would be about eight lakhs, and that it will take about eight lakhs to finish it but we might finish it for less by not providing so much permanent work on it to begin with. The Shahpur branch was designed to irrigate annually 100,000 acres. The present average matured areas on the inundation canals are:—

	Acre.
Government Inundation Canals	43,441
Private Canals	32,580
TOTAL	76,021

The present intensity of irrigation on the inundation canals is about fifty per cent. The present intensity could be increased without danger of water-logging provided there was a good drainage system. The drainage question is being taken up at present. We are working out schemes for aligning and grading all the existing natural drainages. The present intensity varies on account of uncertain supplies in the inundation canals: with an assured supply it would not fluctuate as it does at present.

3400. (Mr. Roberts.) In the Lower Jhelum Colony, American cotton is growing in popularity. The cultivators find that they are getting better prices for it and so they are gradually increasing the area under it. It has been increasing gradually every year and every year you will find a bigger area under American cotton. There are certain reasons against American cotton replacing *deshi* altogether. The cultivators consider that *deshi* has the great advantage that they can mix other crops with it and it is only the better prices that they are getting for American cotton that is inducing them to substitute American cotton for *deshi*. Probably American is a safer crop than *deshi* but they can mix other crops with *deshi* so that it does not so much matter if it fails, as they still have their other crops to look to. The other crops are melons, *moth*, and *guara*. Melons are sown with cotton and are off the ground by the end of May or a little later. I have not heard of any case in which another crop has been grown in the same field with American cotton.

3401. As I have said already, provided there is an efficient system of drains, there is no objection to an increase in intensity but it means a considerable expenditure in grading, and in making the drains to start with, and in maintaining them. Up to date we have spent very little money on drains and it is not part of our annual expenditure to maintain drains, so that, to increase the intensity, you would have to contemplate a considerable annual expenditure on maintaining efficient drains. I would start on drains before the water table is raised. I would start immediately. Drainage would keep the table down to about thirty feet. We can have only surface drains: we cannot have any system of deep drains on the Lower Jhelum canal *khadir* tracts because of the flat slope of the country. Drains would allow the flood water to run off quickly and all waste water from breaches in water courses, breaches in distributaries, as well as heavy rain water, would flow off very quickly, and there would be no standing water anywhere in the *khadir* tracts as at present. After heavy rain you see sheets of water all over the country. Of course, on small distributaries and on minors, there are a certain number of breaches every month. The canal cannot be made absolutely breach proof. We have a project for a complete system of drainage. It was worked out as soon as the canal was made. The drainage channels have never been properly demarcated and properly graded and maintained and cleared especially in the *khadir* tracts. There are certain places where the water courses from inundation canals go right across drainages and obstruct them. Crossings should have been provided, such as aqueducts or syphons. The natural drainage of the country has been obstructed. Provided the natural drainages are kept clear all over the tract, I think there would be no objection to an increase in intensity.

3402. The figures that I have given in my written evidence showing the loss in the various parts of the canal are not up to date. They are from experiments made in the time of Mr. Kennedy i.e., about 1890. It is not exactly the same now. A larger amount than 28 per cent. now reaches the fields. I should say the percentage is more like 40 or 45 per cent. Then it puts the main loss on the main canal, on the distributaries and on water courses. Of course, there is a great deal of waste in the fields too. The *zamindars* have never economised water as they might have done on the Lower Jhelum Canal because there has always been plenty of it even in the *rabi* so that they never worried about dividing the fields into plots or

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"*kiaris*" and we have never forced them to do so to any great extent. From this point of view, I do not think that lining of canals would very largely prevent the rise of the water table as you would still have the waste in the water courses, and in the fields. There would still be no inducement to the cultivators to economise water by making small *kiaris*. The ideal size of water course which we try to work to is two cusecs. In some cases, we allow up to three cusecs but never more than three and never less than one. When we have three cusec water courses, the three cusecs never flow down one branch. We generally have two or three branches carrying one cusec each. Up to date, the cultivators have not put in a sufficient number of *kiaris* because they have had plenty of water and they never bothered to spread it into *kiaris*. The average supply is higher in the *rabi* than in the *kharif*: if you take the average for the whole of the *rabi*, it is 75 per cent. and the average for the whole of *kharif* is only 73 per cent. Taking the six months of *rabi* and the six months of *kharif*, there is very little difference. The proportion on the Lower Jhelum is two *rabi* to one *kharif*; on the Lower Bari Doab it is $\frac{2}{3}$ *rabi* to $\frac{2}{3}$ *kharif*. I think it is practically two *rabi* to one *kharif* on the Lower Chenab. These figures applied before the Triple Canal project came into effect.

3403. This year was no use at all in showing what the effect of the Triple Canal will be. Last year was only the first year and it was also an exceptional year, as it was exceptionally dry. So far, we have not had what one would call an average year with conditions such as they will be when the Triple Canals are all working. It will probably be some years before we arrive at average conditions because the Lower Bari Doab is still being developed. A shortage of water would certainly enhance the demand in *kharif*. Supposing we had a series of dry years like last year. I think that the area under *kharif* would undoubtedly increase. People would begin to realize that the *rabi* supplies were going to be short and so they would begin to do more *kharif*. That is exactly what happened on the Upper Bari Doab Canal where the *kharif* area has gradually increased as years have gone on so that now they have a proportion of one *rabi* to one *kharif* on that canal, simply because there is such a shortage of water in the *rabi*. We could give more water in *kharif* than we are giving but there is no demand as there is plenty of water in *rabi*.

3404. I have not seen any signs of the cropping quality of the soil going down on the Lower Jhelum. On the whole, the soil all over the canal is distinctly good and there have been no signs of any deterioration anywhere. The cropping is very lacking in leguminous crops. Practically nothing is grown to keep the soil in good condition. There is little *senji* or *shaftal* or clover compared with other canals. It seems to me that the grants of land on the Lower Jhelum Canal were very liberal; people got more land than they could cultivate and the result is that they do not make full use of the land that they have. This will cure itself as years go on and the pressure of population begins to make itself felt, and prices go up. The people will then have to work harder and will cultivate more of their holdings, but as I have said, they have been very unenterprising so far. They might do a good deal more than they actually do. It is not owing to want of water that they do not do it.

3405. If the proportion between *kharif* and *rabi* were much altered, I do not think there would be so much difficulty on the Lower Jhelum Canal as there would be in some other canals because we have not about forty miles of main line, and at the end of it we have three big branches. We could thus run full supply in one branch and close the others down. Where there is a long main canal with branches taking off, there are difficulties in the *rabi*, as the supply is running at a lower level, and you cannot get water into the higher distributaries from the lower level. That is particularly the case in the Lower Bari Doab Canal where there is a long main line. It is not such a drawback on the Lower Jhelum, where there are only forty miles of main line and we have only three comparatively small distributaries taking off it. It will be difficult in the case of these three distributaries of course, but then they affect only a comparatively small area out of the total of the whole canal.

3406. As to the remodelling of the Lower Jhelum Canal, it was anticipated that there would be a great shortage of water in the *rabi* and that there would not be enough to go round the quintuple system of canals. It was thought that it would be necessary to reduce the proportion of *rabi* irrigation on the Lower Jhelum and increase the *kharif* so as to make more water available for other canals especially for the drier tracts of and such as the tracts at the tail of the Lower Bari Doab Canal. The idea was that it was more beneficial to use water in the drier tracts rather than in the upper tracts which got more rain. That was the original idea of reducing the amount of *rabi* irrigation in the Lower Jhelum so as to make it available for other tracts. The scheme is in abeyance at present and it will probably remain in abeyance for several years until we see what is the real effect of the Triple Canal Project and how the supplies work out in the winter. We are only in the second year, and we shall probably have to wait about ten years before we can see what the average effect is going to be. Only if there were a shortage in the *rabi* for two or three years running, would the question become acute. On the Lower Jhelum, we have some room for expansion, but there is no justification for altering the proportions at present. There will be a tendency for an increase in *kharif* crops during the next two years. If we have any more dry years like the last year, there will be a decided tendency to increase the *kharif* but it so happened that this year was exceptionally wet and we had exceptionally good supplies in the winter.

3407. The present high price of cotton would tend to some extent to increase cotton under the inundation canals but the supply on those canals is very uncertain and begins very late. The Shahpur branch scheme is feasible from the engineering point of view but there are political objections, which unfortunately still exist. I could not say what I expect there from long staple cotton. The supplies are so variable and you may get very heavy floods in the river which inundate the country and drown out the cotton. You may also get heavy falls of rain which spoil the cotton but the chief cause of the deterioration of the crops under the inundation canals is the liability to floods which cannot be controlled. It is a tract where immediate improvement in the growing of long staple cotton is possible by completing the Shahpur Branch, as mentioned before.

3408. (Mr. Henderson.) The question of drainage requires to be tackled at present only in certain tracts. The only tracts on the Lower Jhelum Canal which at present require to be tackled are the low tracts near the river. The high bar land is still all right and will be so for a great many years, but the low land is more liable to floods and inundation and that is where a drainage system is undoubtedly very necessary. There is no trouble at present in the *khadir* tract of the Chonab because we have control there: in the *khadir* tract, of the Jhelum, we have no control owing to the private inundation canals. The question of having an efficient system of drains is much more important than the question of lining canals. There will be no difficulty where the rivers converge to a point. We can practically have only surface drains but we can have them properly graded and keep them properly graded. At present they are not graded; we have deep

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depressions in some places in which the flood water stands for months on end instead of running off freely. The eventual outlets will be in the river lower down. You cannot get any great depth of drain but you could get a uniform slope for the bottom of the drain which would enable the water in the depressions to flow off. It is advisable to work out a drainage scheme for a new canal at the same time as the canal project is worked out. In fact that is always done. On this canal it was worked out but we have not been able so far to carry it out in the *khadir* tracts of the Jhelum river on account of opposition on the part of the owners of the private canals. If you grow more cotton I do not think it would affect the question at all. On the Lower Jhelum Canal apart from the inundation canals you could certainly grow much more cotton than at present because all the water available in the *khariif* is not being utilized. It would not alter the drainage question. It might reduce the amount of *rabi* as the people are not very enterprising and they consider that they can only do so much cultivation in a year. If they did more in *khariif*, probably they would do a little less in *rabi*.

3409. Purely from an irrigation point of view, the constant cropping of wheat is not likely to deteriorate the soil. I cannot say from the agricultural point of view. We are constantly increasing the efficiency of our distributaries and water courses. There is very little *kalar* on the Lower Jhelum. There are certain places where it is found but they are very few indeed.

Mr. J. ASHFORD, O.B.E., M.I.M.E., Superintendent, Central Workshops Division, Amritsar.

EXAMINED AT LAHORE, JANUARY 10TH 1918.

Written statement.

3410. *Work on tube-wells.*—Your witness is concerned primarily with the engineering and construction side of irrigation works, particularly in the design and construction of sluice gates and the machinery for handling them, weir shutters, bridges, tube-wells, pumps and other machinery. He was the initiator of the experiments on tube-wells at Amritsar which led to the development of the type of well which has rapidly come to the front in India, and which it may safely be said has revolutionised many water problems. In addition to developing these tube-wells, he has produced a series of high efficiency pumps for use therewith for every kind of power whether electrical, steam and oil engine, hulloek or manual. His work has resulted in a series of patented designs which have been proved satisfactory in use. About 200 of his tube-wells have been put down, most of which are of large size.

(2) He has put down the first comprehensive irrigation scheme for irrigating a large area by tube-wells. This is known as the Amritsar Hydro-Electric Pumping Installation. Your witness's experimental work was commenced as a result of an inspection note written by Sir John Benton in 1906, in which he drew attention to the water logging effect produced by canal irrigation within the area irrigated by the Bari Doab Canal and he suggested that experiments should be undertaken with a view to developing some satisfactory means of pumping water from the sub-soil by power generated at canal falls and distributed electrically to a number of pumping stations and he further suggested that your witness should undertake the experiments.

(3) Without detailing the experiments that were carried out, interesting though they were, it suffices to say that they resulted in a tube-well patented by your witness by which water has been pumped to the extent of over three cusecs from one well. When carrying out these experiments, ordinary pumps were used, but as these were found to be of low efficiency and to have various disadvantages, your witness found himself forced to take up the matter of pump design and construction, to enable him to get the best results with his wells. This has resulted in his patent pumps which are now in use at a number of installations.

(4) In addition to this work, your witness has found it necessary to study sub-soil conditions to enable him properly to determine sizes and proportions of the tube-wells and pumps suitable to get the required amount of water at any particular site. As a result of those studies, he is now able to test sub-soils found in borings to record particulars of those tests and to engineer tube well installations so that the desired results may be obtained with reasonable certainty.

(5) It has been found that the most convenient size of a pumping unit is one giving a discharge of about two to two-and-a-half cusecs. Such an installation should normally serve an area approximately equal to one square mile, when allowance for fallow areas is made.

(6) Tube-well installations have been installed in most of the districts of the Punjab, and in the majority of cases suitable sub-soil conditions have been found. In certain areas, there has been difficulty owing to the presence of an excessive amount of clay in the sub-soil and in parts of the Delhi District of rock. In those cases where clay is encountered, it has been found that by boring to a sufficient depth suitable water yielding soils can be tapped. In some areas, the water found near the surface is brackish and this can frequently be avoided by boring to a greater depth until sweet water is found, which is generally below a substantial clay bed. The salt water can be excluded by inserting plain pipes where the well passes through that stratum and using the tube-well strainer only where good water is found. It is the usual experience that, where a boring of considerable depth has to be made, the water tapped in the lower strata rises in the tube-well to the same level as that in the upper strata. In one case only, has your witness found a serious departure from this rule and in this, fine sands mixed with clay and pure clay beds were found to a depth of one hundred and sixty feet after which a good fine sand was encountered which promised a good yield of water, but when pumping commenced, the yield was less than expected and a careful examination of the conditions led to the conclusion that the coarse sand found at the depth named was a pocket contained within a surrounding matrix or envelope of clay.

(7) Many other borings have led to the conclusion that normal conditions are the reverse of the above, namely, that clay beds do not extend to a great distance but are local deposits or pockets within the main body of sandy soil. In few instances only have gravels been found within the depths penetrated and it is probable that they will not be found except in the vicinity of hilly districts. The sand is found to vary in its grade to a certain extent but not so much as might be expected, and it is generally of a grade which in other countries would be classed as fine sand.

(8) Your witness manufactures tube-wells ranging in size from three to twelve inches in diameter. The small sizes are used in conjunction with manually operated pumps or to place in the bottom of *zamindars'* wells to augment the supply and where the ordinary Persian wheel is in use.

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(9) Experience shows that volume of water can best be obtained by using a suitably long strainer in the tube-well rather than by depending upon diameter. With a sub-soil of given gradation, a certain amount of water can be obtained from each foot of its depth with a given infiltration head and while increased diameter to a limited extent assists the inflow of that water, yet it cannot materially increase the volume. On the other hand an increased length of strainer taps the water from an increased depth of sub-soil and thereby proportionately increases the volume. Experience shows that with sub-soil as found in this country, water will flow more freely in a horizontal direction than it will in a vertical direction. This is due to the natural conditions under which the soil has been deposited and to occasional horizontal streaks of clay found in the sands, which have a blanketing effect.

(10) The limitation which so far has been placed on the diameter of tubes installed by your witness is due to the greatly increased cost of the tubing necessary to carry out the work when of still larger size and such tubing cannot now be obtained.

(11) It has been stated in this note that a pumping unit of from two to two-and-a-half cusecs will serve an area of approximately one square mile. This is rather a larger area than is served by an equivalent quantity of water supplied by flow irrigation. According to irrigation reports, the duty obtained by water measured at distributary heads is 250 to 300 acres per cusec. There is, however, loss of water between the point where measurement is made and the fields under irrigation. Thus, as the tube-well can be placed within the irrigated area, that loss is eliminated. It is also well known that the cultivator when applying water from canals to his land does so too prolifically and equally good results can be obtained by less water with careful cultivation. It is to be expected that when he is paying the cost of pumping the water, he will be more careful in its use and the duty obtained will be 400 acres or more per cusec. A unit of the size named should therefore irrigate from 800 to 1,000 acres per annum. The unit should irrigate at the rate of an acre per hour, thus 800 acres can be watered by pumping sixteen hours per day for two hundred days, so it would seem that the estimate of one such unit per square mile should suffice.

(12) A two-cusec unit in a normal situation will require a ten-inch tube-well with a strainer from 120 to 150 feet long. If fitted with an ordinary pump this will take 16 to 20 H. P. to drive it, but if fitted with Ashford's Patent Pump, it will take from 12 to 16 H. P. A good type of oil engine would give this power with one gallon of fuel oil per hour, and if the engine is capable of using crude oil, it will cost five annas per gallon. After allowing for the cost of lubricating oil, labour and other sundries including interest and depreciation, the cost of one watering per acre should come to not more than one rupee. Thus the five waterings required by a cotton crop would cost about Rs. 5 per acre. The cost of such an installation at pre-war prices was about Rs. 7,500 which represents a capital expenditure of Rs. 11.7 per acre. One zamindar who puts down a tube-well installation on his land which previously had been irrigated by Persian-wheels, informed your witness that the first year's crops gave an increased yield sufficient to pay the whole cost of the installation.

3411. *Tube-wells in the hands of zamindars.*—It must be acknowledged that the average zamindar has experience in the use of machinery required to pump water from wells and he is absolutely in the hands of such a *mistri* as he may employ to look after his engine. The average *mistri* when left to his own devices is not good at keeping machinery in satisfactory working order; whether from lack of knowledge, of interest in his work or laziness, it is too frequently a fact that he soon allows the machinery to get into bad condition. Having installed the pumping plant, the zamindar's interest will be concentrated upon using the water it supplies and so long as it is forthcoming he is not likely to concern himself with the condition of the machinery. Rapid wear and tear as the result of neglect too often means a falling off in efficiency of the engine and in the supply of water from the well. The *mistri* will doubtless assure his employer that the machinery in his care is working properly and will throw the blame upon the tube-well. Such instances have come to your witness's knowledge and an investigation has shown the fault to be in the failure of the *mistri* to keep the pump or the parts in proper condition. The class of oil engine which uses crude oil requires more skilled attention than one which uses a higher grade of oil. Thus it may be considered more satisfactory to install the latter type of engine, although the cost of working with the higher grade oil will be higher than that named, to the extent of about Re. 1-8-0 per acre. These considerations lead to the question as to the advisability of such installations being put down unless provision is also made for proper supervision.

3412. *The Hydro-electric Installation at Amritsar.*—The Hydro-electric Installation, which has been put down by the Irrigation Department near Amritsar is situated on a branch of the Upper Bari Doab Canal. The site selected is at a fall on the Main Branch Lower near the Grand Trunk Road, three miles from Amritsar City. At this site there is a fall of 5½ feet. There is another fall of four feet two miles below the site and the scheme provides that this reach of the canal shall be deepened to fuse the two falls into one. When that is done, there will be sufficient power to drive the pumps for sixty tube-wells of two cusecs capacity. It is not the intention, however, to use the whole of the power for this purpose, but to divert a portion to the Central Workshops for use there. Consequently the number of wells that will be installed in connection with this installation is not likely to exceed fifty. When the scheme was first sanctioned it was not expected that more than thirty such wells could be used, but the production of the improved pump already referred to has made the larger number of units possible. Electricity is generated at the power station by three sets of turbo-generators, at a pressure of 6,600 volts, at which it is transmitted along lines to transformer stations where the pressure is reduced to 550 volts. It is then conveyed by low tension lines to the pump stations, each sub-station serving six pumps.

(2) This installation has been entirely engineered by your witness and the staff of the Central Workshop Mr. Leggett, Assistant Superintendent, having been placed in immediate charge of the work. The pumps installed, of which fourteen are now in use and, with one exception of the type mentioned, and their design is such that one attendant can look after one sub-station and the six pumps controlled therefrom. As part of the power is used at the Central Workshops, the balance of the pumps will not be installed until the reach of the canal is deepened because until that work is done the power station will not reach its full capacity.

(3) The estimate of the number of tube-wells that will ultimately be driven from this power station is based on the measured power consumption of the pumps already in use. The water level in this area is about ten feet below ground and the power consumed to pump from two to two-and-a-half cusecs is from 11 to 14 H. P. or 5.5 H. P. per cusec.

3413. *Prospects of suit and schemes.*—A similar scheme to the above directed to irrigation work entirely would operate sixty pumps under similar conditions and these should irrigate an area of 48,000 acres per annum. Such a complete scheme would cost approximately Rs. 11,00,000. This gives a capitalisation of Rs. 22.4

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[Continued.]

per acre. As the generators at the power station are driven by water power, there is no expenditure for fuel, consequently the cost of working with full allowance for depreciation of plant, repairs, attendance, etc., would be covered by a revenue of Rs. 3-12-0 per acre and would give a return of eight per cent. of the capital.

(2) It is not possible at all sites to have a water power installation such as that described above, but it would be possible to put down a power station to produce electricity and to operate pumping installations in a similar way. Such a plant with steam engine and boilers for the production of the power would have a capitalised cost of about Rs. 10,00,000. The cost of working it would be greater as it would include the cost of fuel and the additional attendance entailed by the stoking of boilers. Such a scheme with a revenue of from Rs. 4-8-0 to Rs. 5 would be a paying concern.

(3) The greatest advantage of a power installation of such a size as that named is that it would be run by a proper engineering staff with skilled mechanics under expert control. Its efficiency would consequently be maintained and would not depend upon the doubtful skill of the village *mistri*. It appears to your witness that the introduction of the tube-well, which he initiated, has made it possible to bring land under cultivation for growing cotton and other crops in areas that are not commanded by irrigation canals and their use is likely to be great in bringing back into cultivation areas that have been damaged by water logging. They can also be advantageously used in conjunction with canal irrigation to take up duty during periods of canal closure which in case of cotton crops often occur at the most critical period.

Mr. J. ASHFORD, O.B.E., called and examined.

3414. (President.) I have been closely identified with tube wells. I have already a big hydro-electric pumping scheme. There are very few places in the Punjab where you cannot get water by tube wells. We can always supplement our irrigation schemes by using them. The whole province could practically be made an irrigated province by using power from the canals where available and other power where it is not. The cheapest method of obtaining water from pumping is to develop electric power from a waterfall and to distribute it electrically to the pumps. The work that I have done shows that a properly engineered scheme of that description makes it possible for irrigation by pumping to come within the figures now charged for flow irrigation. I have worked it out very carefully. From the user's point of view, there is nothing against it.

3415. The hydro-electric installation that I have put down at Amritsar is not yet fully developed. There are two falls on the canal about two miles apart, and the scheme cannot be developed until the fusing together of the two falls in the canal has been carried out. The upper fall is five or six feet high and the lower four feet and the canal is to be deepened between the two to make them into one. The hydro-electric plant is at present working on one fall only. That, of course, means that the turbines are working under conditions which are not favourable. They cannot produce their full power. Considering the other end at which the pump is worked, I have succeeded in producing pumps with a very high degree of efficiency for use with the tube wells.

3416. I find that such an installation as we are putting down would work sixty tube wells and pumps, the capacity of each one ranging from 2 to 2½ cusecs, allowing a duty of 400 acres per cusec per annum and charging the normal canal rates, I have worked out that the whole scheme will pay about eight per cent. after allowing for depreciation. There is one point that I have not included in my estimate, and that is the cost of the establishment which deals with the final control of the water, i.e., the *patwari* establishment. My estimate includes all the engineering establishment up to the point at which the water is put into the water courses. I have taken my estimates still further. I have assumed that there are tracts where there are no falls but where power could be generated and considered the state of affairs that would then exist. I have estimated that a similar scheme with central power station and electrically driven pumps, working sixty wells, the generators being driven by steam engines and boilers, would cost about ten lakhs. Providing that coal can be obtained at about Rs. 15 a ton, with a revenue of about Rs. 5 per acre, it would be a very good paying concern. Steam power is more expensive than hydro-electric. By engineering such schemes on a large scale, I think there is no doubt that irrigation could be done at a rate which would be very good from the *zamindars'* point of view.

3417. There is another point which I have broached in my note. A single tube well driven by an oil engine undoubtedly pays the *zamindar* when it is properly run and looked after. Unfortunately, there are not enough skilled *mistris* available to look after such things properly. So long as the machinery is kept in good condition, they undoubtedly pay the *zamindar* well. A *zamindar* probably knows nothing about pumps and engines and is therefore entirely in the hands of his *mistri* and too often he allows the pump and engine to get into bad condition. Provided they are looked after properly, even a single unit pays the *zamindar* well.

3418. The estimates in my note were framed on the assumption that the water is ten to fifteen feet below the ground. The actual cost of pumping is, of course, increased, the greater the depth below the ground, but provided it is within forty feet of the surface, it can be done to pay very well. If an adequate and competent staff of *mistris* were available, I would be quite in favour of small installations by *zamindars* driven by means of oil engines. Failing that, centrally controlled scheme is the best thing. In a big scheme like that, you can afford to pay a proper engineering establishment. I have nothing to say against the smaller installations except to point out the existing difficulty of getting qualified men. I have pointed out in my note that I have come across cases where the *zamindar* a little more intelligent than the average has been careful to see that his plant has been well run and he has made money out of it. A *zamindar* came to me a few months ago and told me that he was becoming a man of wealth owing to the tube well he had. He was the first man to put down one of my tube wells. Another man in Bahawalpur told me that the increased yield from his land due to the installation of a tube well more than paid for the whole cost of installation in the first year.

3419. I am too much tied down to Amritsar to be able to engineer small privately owned plants. My duties at the Central Workshops do not allow me to go about in the Punjab to any great extent. My tube wells have been put down all over the province. With very few exceptions, there has been no difficulty, which shows the wide extent to which they can be used. I have not supplied so many for the Irrigation Department as for private individuals, railway works, Municipalities and Military works.

3420. (Mr. Ashton.) As to the depth of the water below the ground for pumping by tube wells, I may say that I have worked out a scheme so that I can pump from any depth. Consequently, the limit is not due to engineering difficulty but it is a financial one; that is the cost of pumping. I take it that with the higher rates which now obtain for agricultural produce, it would really pay to pump from a considerable depth

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3421. The last sentence of my written evidence does not refer entirely to inundation canals. If I am correctly informed by one of the senior officers in the Department, it is the experience occasionally that during the monsoon, when the river rises in flood, the canals have to be closed. This closing may come just at the critical time when the cotton crop needs water and may throw out the rotational working. The closures are only for about 48 hours but that throws certain cultivators out of their turn. If pumps were only to be used to fill this gap, for the rest of the time they would be lying idle. There is the further point that in a given area, if you put down a pump and a tube well, it is not advisable that they should stand idle. By a combined system a portion of the area could be worked by tube wells and the remainder by flow irrigation and the fact that you had tube wells there would enable the critical watering to be given and thus save the crop. As to the area which could be irrigated by the tube wells, I would arrange so that normally the tube well would be irrigating its full area, i.e., out of an area of 3,000 acres, the cultivator would perhaps put 500 acres under the tube well. The whole would not be under one crop, so at the critical period, water from the tube well could be used for those crops, normally getting flow irrigation, which were jeopardised by the closure.

3422. (Mr. Henderson.) I was able to get over the difficulty in regard to the clogging of strainers at an early stage. The experiments we carried out went to show that the form of the strainer then available would clog and experiments were conducted to find a form of tube well that would not clog. That is the particular point of my tube well. In fact the first one that I put down, of my particular design, has now been working for six years and is giving as much as or perhaps a little more than it gave at first. As to the possibility of scum growing on the strainer, there has been one instance where it has occurred and that was at Dera Ghazi Khan. It was a form of growth which commenced in the water pipes of the distribution system. It has given trouble there but that is the only case that I am aware of. I am not a bit frightened in regard to it for the simple reason that tube wells have been used for a considerable time and we have had no other complaints so far. Even if there were some difficulties it is possible to take the tube well up, clean it and reset it.

3423. As to whether the zamindars should use oil engines or boilers, I should say that the position must be controlled by local conditions. An oil engine is very good if kept in good working order. There are cases where one has to depend entirely on coal, and in such cases steam, of course, would be used. I know of some zamindars who have installed steam engines as they have a fair amount of jungle on their land which they could use for fuel. They use cotton stalks as fuel and also the crushed sugarcane stalks. Generally speaking, I would recommend a simple type of boiler, one that can be easily cleaned and not a multi-tubular one. I find that portable engines cannot be repaired by an ordinary *mistri* and they are frequently allowed to become choked with mud. That would be a cause of trouble. The objection to a portable engine for driving a pumping installation is that it might be classed as a fuel eater. It is very uneconomical for pumping water and I take it that economy of working is a very important point. In case cotton stalks were used there would be a limit to the quantity available.

3424. One rupee an acre is the probable figure per watering with water at an average depth of fifteen feet. The average general depth in many areas lies between fifteen and twenty feet. There are areas where the surface water is salty but we have been able to get over the difficulty by boring to greater depths and pumping sweet water. In every case, so far, the difficulty has been got over. I find that the salt concentration is usually over a fairly continuous clayey bed and that when you can get through that clayey bed, you are likely to get sweet water below provided, of course, you go far enough down. Take Lahore; there are quite a number of my tube wells there. Much of the surface water is brackish, but about sixty feet down there is a bed of clay ten feet thick and when you get through that, you get fresh water. In Lahore Cantonment there is one of my tube wells. The surface water was condemned as unfit for the consumption of troops. A boring was put down 300 feet, a good clayey bed was found at 180 feet and below that the water was sweet.

3425. I have done a certain amount of boring in existing wells to increase the supply of water. The objection to putting a tube in an ordinary well is that the ordinary well limits the head of pumping. The outturn of the tube well is proportionate to the infiltration head. As you draw water out of the tube well you decrease the water level in it and the difference of level inside and outside causes the water to flow into it. The yield is then proportional to the difference. Therefore, if you have a tube well in an ordinary well, you are limited in regard to the infiltration head which you can apply by the fact that the sand draws in. You are thus limited in regard to infiltration by the ordinary well. If you pump too much, the sand rises up and blows into the ordinary well which sinks or collapses. With tube wells you have not that limitation.

3426. It is the tendency of the existing masonry wells in the canal areas to fall into disuse, chiefly because pumping by bullock power is much more expensive. In Amritsar, we are putting up pumps which will be worked by power derived from the main canal. Where there are areas which the canal does not command, it would be a good thing to irrigate by means of such pumps. There are many such areas near the main canal and by utilising the power of the canal falls you could irrigate that area or with oil engines and pumps.

Mr. W. F. HOLMS, Chief Engineer, Irrigation Works, Punjab.

EXAMINED AT LAHORE, JANUARY 10TH 1918.

Written statement.

VI.—IRRIGATION.

3427 (50) Experience.—I have been in the Punjab Irrigation Branch over 26 years and, except for about seven years, spent on leave, have been connected with open running canals as Assistant, Executive, Superintending and, for the last twenty months, as Chief Engineer.

3428. (51) Wheat versus cotton.—Wheat is a long way the favourite crop in the Punjab. Cotton on some canals, e.g., the Western Jumna Canal and Upper Bari Doab Canal is a good second and approaches the wheat areas, but, on the Sirhind Canal, its area is small, seldom even one-tenth of that under wheat, even though the water rate there for wheat is 33 per cent. greater than for cotton. These are the three chief canals in my charge. The reasons for the preference for wheat over cotton probably are that it requires far less labour both as regards irrigation and other treatment, is less likely to be damaged by disease or by excessive

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rainfall, is easier to handle and store, is hardier, is not so long on the ground and not so dependent on regular irrigation, while the fluctuations in the price of cotton are far greater than those of wheat. In short, the Punjab *zamindar* and his womenfolk have found by experience that wheat suits their pockets just as well and their natural inclinations much better than cotton.

3429. (52) (a) Critical period in regard to water supply.—The most critical periods are, on the Upper Doab and Sirhind Canals, probably from about 15th September to end of October, and 15th February to end of March. If the supply is plentiful from 15th September to the end of October, there is generally water for a large wheat area as well as for *kharif* crops such as cotton and sugarcane, while good supplies after 15th February go far to secure the maturing of the *rabi*. On the Western Jumna Canal, the early autumn supply is generally good but the Jumna river rises late in the spring, probably quite six weeks, on an average, later than the Sutlej and Ravi rivers, which serve the two other canals named. On that canal, therefore, the critical period may extend from February into early summer. Sugarcane is a very valuable crop on the Western Jumna Canal and if water were short, say in March, the people would use it for cane not to speak of wheat in preference to cotton.

(2) If the *deshi* cotton area were increased, it would probably not much affect the pressure on the water supply on the Upper Bari Doab and Sirhind Canals in spring but, if the increase were of the American cotton area, which, it is understood, requires water both earlier and later than the country variety, it would have that effect both in spring and autumn. On the Western Jumna Canal, the strain during the critical period would be intensified from the middle of March till about the end of May either by a large increase in *deshi* or by a substitution of American for *deshi* cotton.

3430. (52) (b) Watering of cotton.—*Deshi* cotton requires water ordinarily from about the 10th April and takes its last watering early in October. It generally gets six waterings, the first perhaps six inches or seven inches in depth and the other four inches or five inches varying with the rainfall and locality: it probably requires much less.

3431. (52) (c) Statistics.—Annexures I and II give the statistical information for the Western Jumna and Upper Bari Doab Canals. The Sirhind Canal is not included because the comprehensive Bhakra Dam Reservoir Scheme will change everything on that canal and will, if carried out, utilize pretty well all the water that the Sutlej can supply. The inundation canals generally begin to flow too late to have large cotton areas, even of the *deshi* variety and the American kind would be still more unsuitable there.

3432. (53) (c) Possibility of expansion of area under cotton by enlargement of canals.—Annexures III and IV put up contain the material to answer this question decidedly in the negative. The statements only refer to the Upper Bari Doab and Western Jumna Canals because, as already indicated, the conditions of Sirhind Canal are likely to be changed in a drastic manner but, if not, the same process of reasoning would apply to that as to the other two canals specified.

(2) For an enlargement of a canal to produce an expansion of the cotton area one condition must obtain, viz., the canal must not be large enough to take available river supplies for which there is a demand in sowing time or in the critical period of supply as regards maturing. Now a careful study of Annexures III and IV will show that on no single day during the five Octobers ending 1917 did either the Upper Bari Doab or Western Jumna Canal carry its full supply and in fact the full supply was very seldom approached, and only on nine days out of 155 did the Upper Bari Doab Canal carry over 6,000 cusecs, though it is capable of carrying 6,700 cusecs, while the Western Jumna Canal never once during these five years in October carried as much as 6,000 cusecs, the most it carried was 5,812, though capable of carrying 6,430 cusecs. It is immaterial whether these results were due to short supply in the river or to absence of indent on the canal: in the former case, it would obviously be useless to enlarge the canal to pass what we have not got to pass and, in the latter, to take in that for which there is no demand.

(3) A study of the canal discharges (Annexures III and IV) in March, April and May leads to a similar conclusion. During five years in March, neither the Upper Bari Doab Canal nor the Western Jumna Canal, which can carry 6,700 and 6,430 cusecs, respectively, ever ran on any one day more than 6,000 cusecs and only on six and three days, respectively, over 5,000 cusecs. Out of the 150 days in the five Aprils, the Upper Bari Doab Canal only on six days ran over 6,000 cusecs and never full supply, while the Western Jumna Canal on no occasion took 6,000 cusecs and only on twenty-two days over 5,000 cusecs. Then in the 155 May days, the Western Jumna Canal on only two passed over 6,000 cusecs, while the Upper Bari Doab Canal on twelve days took nearly (6,650 or over) full supply. The figures given above show clearly that no expansion of the cotton area can be looked for by increasing the capacities of either the Upper Bari Doab Canal or Western Jumna Canal. In March, the sowing month for American cotton, either there is not enough water to fill the present capacity of these canals or when there is ample water after rain or freshets, the demand is slack and there would be no advantage in greater capacity.

3433. (53) (b) Effect of enlargement of canals in area under wheat.—It is no doubt possible that for occasional short periods, towards the end of September perhaps, these canals would benefit slightly by a greater capacity after an early cessation of the monsoon, which might produce an intense demand to mature *kharif* crops and to plough for the *rabi*. Such occasions are rare, and, if regard be had to financial considerations, would not justify wholesale enlargement of these canals, and in any case would not directly affect areas sown under cotton, though, doubtless, they would slightly affect either the matured area of that or other *kharif* crops, or the *rabi* sown area. A proper economy of canal design indicates that capacities should be based on normal not on rare and abnormal conditions of river supply.

(2) It is sometimes urged that enormous extra areas of irrigation would result from larger canals. This is shown to be a fallacy as regards the three canals discussed in this evidence. Did statistics show that these canals run for considerable periods up to their present capacities, the contention would *prima facie* appear reasonable, but statistics do not show this.

(3) It may of course, be urged that the use of dams to conserve the monsoon supply would be helpful. As to this we have in hand an important project for a dam on the Sutlej, forty miles above Ruper. That project may cost nine or ten crores and if carried out at the same time as other big projects, such as the Sutlej valley, estimated to cost over nine crores and Thal Projects will cause great difficulties as to finance, labour and establishment, and subsequently as to colonisation. Later on the question of a dam up the Ravi will doubtless be revived, and possibly one on the Jumna too.

3434. (54) (a) Enlargement in duty of water by remodelling of outlets.—Equalisation of distribution would not necessarily produce an increase of irrigation, least of all where the intensity of irrigation is low. Probably the best duty can be obtained on an outlet, which irrigates a good intensity, say somewhere about eighty or ninety per cent. of its land. If, therefore, equalisation on any channel means

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the reduction of many outlets from an intensity of say 120 per cent. and the increase of many others from an intensity of say forty per cent. to an all round eighty per cent. or ninety per cent. intensity, an appreciable increase of irrigation may be looked for.

3435. (54) (b) Utilization of modules.—Modules would be helpful both as steadying the discharging capacity of the upper outlets and as ensuring a more reliable discharge at the tail. They would remove the power of the irrigators on the upper reaches of benefiting themselves by heavy silt clearance at times of keen demand at the expense of the other irrigators lower down.

3436. (55) (b) Fluctuations in river supplies and their effects.—Numerous rise and fall diagrams are printed in the Punjab Irrigation Department Blue Book ('Statistics of Irrigation, Water Distribution, etc.') and a reference to these is invited. It may, however, be said that the Punjab rivers are snow fed and that in spring once the snow begins to melt, the rise is fairly rapid. In the autumn the decrease is not quite so rapid but, in that season, September freshets obscure the date from which a gradual fall in the river should be considered as beginning.

(2) The cultivators naturally base their agricultural operations on the water condition prevailing or in their experience likely to prevail; for instance, on the inundation canals, there is practically no sugarcane and not a great deal of cotton. Or again on the Western Jumna in 1916, though the prices of cotton were very high, the cotton area was small solely because the river rose abnormally late that year. In 1915, cotton area was low not because of supply, which was ample in spring, but on account of an anticipation of low prices. But, whatever the state of the river or rainfall, it may be said that the Punjabi will put down as much wheat as he can after allowing sufficient fodder crops for his cattle.

3437. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—The tracts which get irrigation only in the summer months are made up of the *khadir* tracts served by inundation canals or of lands with high spring level and favourable rainfall, served by *kharij* channels of perennial canals. Well irrigation of any land is, of course, possible as long as the spring level is not too low, say not more than forty feet. The well irrigation of the tracts specified above would therefore be quite feasible but the people generally dislike the continued labour for themselves and cattle involved in an extensive system of well irrigation, while the great disparity in cost between well and canal irrigation is against the former. It has been calculated that the well irrigation of an acre in *kharij* costs about four times as much as canal irrigation for a thirty feet, lift. It may be doubted, too, whether enough cattle are available, while a large influx of cattle would to some degree alter the areas of fodder crops, etc.

3438. (56) (b) Extension of irrigation under wells in canal areas.—It is on the inundation canal, that the use of water for sowing and maturing cotton would be most advantageous and for some of these the following figures have been abstracted from the Gazetteers and Settlement Reports, though it is not quite certain whether *pukka* wells only are included:—

	Culturable commanded area.	
(i) In the Dipalpur and Pakpattan tahsils of the Upper Sutlej Canal.	There is one well to about	55 acres.
(ii) In the Mailsi and Ledhran tahsils of the Lower Sutlej Canal.	„ „	80 „
(iii) In the Muzaffargarh district	„ „	95 „
(iv) In the Dera Ghazi Khan district	„ „	110 „

Annexure V gives some information about wells on the Western Jumna, Upper Bari Doab and Sirhind Canals.

(2) To extend well irrigation is a difficult task when canal water is sold as cheap as now and when most of the people are content with a modest competence. None the less to preserve the hardness of the Punjabi, to give him security in abnormal years and to secure to him and Government the full benefits of irrigation in such years, well irrigation should be encouraged quite apart from its relation to the important question of waterlogging and from its educative influence as regards economical use of water.

3439. (56) (c) Tube wells.—Tube wells would be useful in this connexion, but if only worked, as suggested in the question, at beginning and end of crop they would not be earning a return on their cost all the time. It is, however, unlikely that any but enterprising men of substance—and there are comparatively few such—will put down tube wells and if any considerable extension of the cotton area takes place by the greater use of wells at certain critical seasons, the wells will probably be the ordinary masonry wells. But such an increase presupposes greater energy and industry on the part of the people, and no practical means of securing these have been suggested.

3440. (56) (d) and (e) Construction of weirs *versus* construction of wells.—Weirs without doubt will reduce the need of wells. They will be especially helpful to cotton because they will enable all the water in the rivers to be utilized, when the rivers are low in spring and autumn none of which can be used without weirs. On the Sutlej we have three weirs estimated or under estimated—one below Phillour, one below Gandasinghwal and another near Jamlera and on the Chenab another below its junction with the Jhelum. The object of these is to give greater control of the rivers—especially when low. These weirs will doubtless have the effect of largely increasing the cotton on the inundation canals, which will cease to be such and of irrigating lands not hitherto irrigated, much of which will grow cotton. But it is not desirable entirely to throw out of use all wells—on the contrary it is right to be able to supplement canal supplies in bad years at the critical time.

(2) It is scarcely possible to make any useful comparison between the cost of improving canals to obviate the use of wells and the cost of safeguarding irrigation by constructing the requisite number of wells. Take for instance the Sutlej Valley project, which includes two weirs and is designed to irrigate about 1½ millions old irrigation and about the same area of new irrigation at a cost of yearly ten crores. Most of the new irrigation—and it is from new irrigation that such projects derive their financial stability—is on high desert ground where the spring level may be one hundred feet deep or more. Well irrigation of such tracts is impracticable, while as regards the million and a half acres of existing irrigation, it may safely be said that the provision of cattle and willing labour to work a huge increase in wells would be even more difficult than

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provision of the funds to construct the same. None the less increased use of wells is worthy of all encouragement. A further examination of the matter seems uncalled for because it has already been accepted that the right policy as regards the inundation canals is the provision of weirs, where practicable, and projects to give effect to this policy are in hand.

3441. (58) Cropping and causes affecting it.—On the Western Jamma and Upper Bari Doab Canals on a 100 acre plot we would find something as under :—

	Western Jamma Canal.	Upper Bari Doab Canal.
Wheat	28	24
Cotton	22	15
Juar	8	14
Cane	8	3
Gram	8	6
Rice	2	6
Maize	Negligible	6
Senji	"	8
Miscellaneous	21	18
TOTAL	100	100

(2) Miscellaneous on both canals would include chiefly barley, *sarson*, *masur*, vegetables and garden, *mool*, *gvara*, *mas*, melons and *toria* on Upper Bari Doab Canal. No proposals put forward would alter these percentages on those canals, but when weirs are built for the present inundation canals, it may be assumed that there the class of crop will improve and cotton area and outturn alike should greatly benefit, that crop replacing *juar*, *chari*, and the lighter crops.

3442. (59) Practicability of lining canals.—I have seen some lining of canals more or less of an experimental nature. On the Upper Bari Doab Canal, Rs. 28,000 were spent on puddling with clay two miles of the Lahore Branch, Rs. 80,000 were spent on a cement slurry lining of about two miles of the Main Branch Lower but this was too thin and failed, and there is a sanctioned estimate for Rs. 1,35,000 of which above half has been spent for a cement plaster lining half inch thick.

(2) There may be doubts as to the practicability of lining within reasonable time the main line of a canal, subject to infrequent closures, where the canal bed is below spring level, a condition which not unfrequently obtains. But, though the advantages would not there be so great, further down the canals the practical difficulties of lining tend to become less, while in the case of a new canal lining would generally present no practical difficulties as to execution.

3443. (60) Cost of lining canals.—Blue books show that the Punjab Major Canals irrigated 7,982,532 acres in 1915-16, while the capital outlay was 2,169.5 lakhs and the return on capital expenditure was 10.9 per cent. The capital expenditure, therefore, per acre irrigated in that year was Rs. 27.

(2) Now take a canal with 120 feet bed width and say 138 feet wetted perimeter. In 5,000 feet length, the wetted area would be 69 million square feet and allowing ten cusecs absorption per million there would be 6.9 cusecs absorption, of which assume that lining would save six cusecs. Six cusecs saved in the upper reaches of a canal might irrigate 1,500 acres lower down, and the cost of lining 138' \times 5,000' at Rs. 20 per 100 square feet would be Rs. 1,38,000, or $\frac{138,000}{1,500}$ = Rs. 92 per acre, which compares unfavourably with the Rs. 27 arrived at previously.

3444. (61) Enlargement and lining of canals.—It is scarcely possible to give a general answer to these two questions and even in any particular case one would have to know the length of closures permissible and certain physical features such as spring levels, which if high might make the rapid execution of masonry works impossible. In the past, canals, e.g., Upper Bari Doab Canal designed, it is believed, with about half its present capacity, have been enlarged gradually, not 'per saltum.'

3445. (62) Effect of lining canals on seepage problems.—The effect would, of course, depend on the efficiency of the lining, but it may be doubted whether any result it would produce on seepage problems or subsoil water table, would materially alter cotton areas.

3446. (63) Effect of lining canals on supplies.—The lining of canals would, generally in the summer months, not appreciably improve the supply. Annexures I and II of average monthly discharges in the summer show that these are far below the maximum carrying capacity of the canals and, if more water were wanted, then it could readily be run. In the winter months, however, lining would improve the supply, because then we cannot supplement any shortage by putting more water in at the head of the canal. Taking the example given in reply to question 60 (paragraph 3443) and assuming that the 1,500 acres arrived at will produce Rs. 6,000 revenue on the Rs. 138,000 spent, we would get a return for our money of about 4½ per cent. It may, however, here be noted, having regard to what has just been said about lining not improving the summer supply, that 1,500 acres would be rather much to allow for the six cusecs saved higher up, equivalent to perhaps five cusecs lower down, 200 acres rather than 300 acres per cusec might be taken giving 1,000 acres instead of 1,500 acres and 3 per cent. instead of 4½ per cent.

3447. (64) Suitability of water rates.—The pitch of water rates hitherto adopted seems to have influenced the *zamindar* but little in his choice of crops. The rates are generally too low to have that effect and were suitable enough having regard to past conditions and the natural course of taking up the easier irrigation projects first. But now that only the more costly and difficult projects are left, a rigid adherence to past practice of low rates may make it increasingly difficult to justify these projects on the lines hitherto laid down, even though the projects be undoubtedly sound in themselves, and would greatly add to the wealth of the country. Subject to the remark, that water rates in this Province are generally low and that those on the Upper Bari Doab Canal unaltered for over quarter of a century, despite great rises in the price of produce, are now under reconsideration, no criticism is offered as to the numerous Schedules of Rates in force. The opinion is however firmly held that no practicable change in the water rates for cotton will appreciably affect the area under the crop.

(For the oral evidence of this witness see page 101 below.)

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[Continued.]

ANNEXURE I.

Statement showing average monthly flow of Western Junna Canal and average monthly area of each crop irrigated.

Particulars.	KHARIF.					RABI.					REMARKS.			
	April.	May.	June.	July.	August.	Septem-ber.	October.	1. Novem-ber.	Decem-ber.	January.	February.	March.	Total.	Percentage.
WESTERN JUNNA CANAL.														
Maximum discharge authorized	..	..	..	..	..	5,129	..	..	..	..	..	..	..	..
Monthly average discharge during :-														
1914-15	4,912	4,038	5,231	3,690	2,373	5,914	1,031	1,256	2,961	2,910	2,436	3,227	..	..
1915-16	4,048	4,474	1,170	4,771	4,944	4,769	4,647	2,075	2,281	1,888	1,842	1,560	..	..
1916-17	1,771	2,071	4,124	4,789	2,373	3,461	3,000	3,299	3,552	2,655	3,063	2,070	..	..
AVERAGE OF THREE YEARS	3,577	3,721	4,620	4,417	3,565	4,652	3,010	3,529	2,931	2,497	2,447	2,280	..	..
PRINCIPAL CROPS.														
Average area irrigated during the three years ending 1916-17—														
Sugarcane	31,563	32,417	4,768	1,321	150	63	..	..	..	..	..	..	70,319	10-14
Rice	..	22	1,022	8,616	5,096	1,397	..	..	..	..	..	..	16,783	4-57
Cotton	6,814	51,531	44,873	20,023	5,953	2,557	..	..	..	..	..	..	137,811	37-51
Indigo	76	2,051	1,459	1,290	161	61	..	..	..	..	..	..	5,12	1-30
Maize	41	102	75	534	353	413	..	..	..	..	..	..	1,518	0-42
Juar and chari	1,407	9,079	8,039	21,575	15,837	14,766	..	..	..	..	..	..	74,543	20-28
Miscellaneous	17,962	16,031	8,447	14,305	3,331	1,107	..	..	..	..	..	..	61,322	16-60
													1307,485	100-00
Wheat	..	..	..	..	..	..	3,821	35,894	115,092	48,026	7,721	1,216	215,373	49-14
Barley	..	..	..	..	..	..	82	1,553	8,577	2,508	562	205	18,947	3-12
Mixed grain	..	..	..	..	..	..	471	10,349	32,957	9,407	1,005	1,141	50,203	12-56
Sesoon	..	..	..	..	..	..	45	517	3,104	977	265	141	5,079	1-14
Gram	..	..	..	..	..	..	3,351	16,110	45,533	12,180	2,612	2,033	80,019	17-89
Senji	..	..	..	..	..	..	3	140	41	1	1	..	189	0-04
Miscellaneous	..	..	..	..	..	..	23,961	44,538	12,037	-2,404	-390	441	78,783	17-61
Sugarcane	..	..	..	..	..	..	..	-2,355	23	..	..	..	-2,312	-0-50
													447,371	100-00

The areas of the crops are those recorded month by month by the patwari. The new cotton areas shown in July and subsequent months were probably sown "barani."

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Mr. W. F. HOLMS.

[Continued.]

ANNEXURE II.

Statement showing average monthly flow of Upper Bari Doab Canal and average monthly area of each crop irrigated.

Particulars.	Kharif.						Rabi.						REMARKS.
	April.	May.	June.	July.	August.	Septem-ber.	October.	Novem-ber.	Decem-ber.	January.	February.	March.	
UPPER BARI DOAB.													
Maximum discharge now authorized	..	..	..	..	6,700	..	..	..	..	..	..	..
Monthly discharge, 1914-15	4,925	0,051	0,436	4,443	4,809	4,789	4,635	3,739	3,205	2,780	1,536	3,080	
Ditto 1915-16	3,867	0,229	6,297	6,401	0,003	5,087	3,445	2,583	1,970	1,001	2,074	3,238	
Ditto 1916-17	4,745	5,362	6,1	5,177	3,840	4,800	4,127	2,380	1,817	1,598	1,501	1,882	
AVERAGE OF THREE YEARS	4,512	5,881	0,292	5,340	5,084	5,192	4,009	2,901	2,331	2,013	1,720	2,930	
PRINCIPAL CROPS.													
Average area irrigated during the three years ending 1910-17.													
Sugarcane	0,674	12,093	8,305	2,036	460	704	..	..	..	..	..	..
Rice	13	756	0,580	27,018	17,033	0,804	..	..	..	..	..	..
Cotton	12,488	05,898	49,598	3,149	3,140	3,394	..	..	..	..	..	..
Indigo	..	..	4	..	..	..	..	..	..	..	..	..
Malze	477	1,334	2,172	5,607	25,334	19,990	..	..	..	..	..	..
Juar and Char	3,493	17,080	28,005	14,377	15,175	5,035	..	..	..	..	..	..
Miscellaneous	47,733	53,060	06,727	9,701	16,823	8,988	..	..	..	..	..	..
Wheat	..	..	..	..	..	..	14,012	50,144	105,095	40,405	11,137	10,078	
Barley	..	..	..	..	..	..	458	591	2,210	1,272	465	893	
Mixed grain	..	..	..	..	..	..	6,972	24,746	52,331	25,131	5,020	6,078	
Sarsen and Toria	..	..	..	..	..	..	452	437	1,347	1,474	332	935	
Gram	..	..	..	..	..	..	12,807	10,738	29,484	13,530	1,047	—125	
Senji	..	..	..	..	..	..	8,099	10,142	38,450	17,227	633	8,312	
Miscellaneous	..	..	..	..	..	..	85,537	33,581	—4,371	—7,002	—5,399	—4,631	
These are only Shudhar figures obtained from the monthly state-ments of Irrigation Operations.													

These are only *Shukar* figures obtained from the monthly statements of Irrigation Operations.

The areas of the crops are those recorded month by month by the *pachari*. The new cotton areas shown in July and subsequent months were probably sown *barani*.

Mr. W. F. HOLMES.

[Continued.]

Date.	1913.			1914.			1915.			1916.			1917.			Remarks.
	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March.	April.	May.	
1	1,720	2,080	2,050	2,110	2,127	2,114	2,097	2,053	2,037	2,053	2,037	2,053	2,037	2,053	2,037	Canal closed.
2	3,754	4,123	3,785	3,416	3,927	3,712	3,711	3,694	3,694	3,694	3,694	3,694	3,694	3,694	3,694	Canal closed.
3	4,129	4,133	4,032	3,416	3,759	3,691	3,712	3,712	3,712	3,712	3,712	3,712	3,712	3,712	3,712	Canal closed.
4	1,253	4,167	3,176	3,178	3,178	3,178	3,178	3,178	3,178	3,178	3,178	3,178	3,178	3,178	3,178	Canal closed.
5	2,160	4,221	2,350	3,622	4,127	4,226	4,127	4,127	4,127	4,127	4,127	4,127	4,127	4,127	4,127	Canal closed.
6	3,329	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
7	2,312	4,519	3,511	3,622	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	4,012	Canal closed.
8	2,558	4,179	3,553	3,073	4,012	3,073	4,012	3,073	4,012	3,073	4,012	3,073	4,012	3,073	4,012	Canal closed.
9	2,729	4,259	3,037	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
10	2,850	4,153	3,637	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
11	2,729	4,102	3,011	3,073	4,012	3,073	4,012	3,073	4,012	3,073	4,012	3,073	4,012	3,073	4,012	Canal closed.
12	2,715	4,129	3,635	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
13	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
14	2,632	4,859	3,102	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
15	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
16	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
17	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
18	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
19	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
20	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
21	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
22	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
23	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
24	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
25	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
26	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
27	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
28	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
29	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
30	2,729	4,223	3,213	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	3,259	4,012	Canal closed.
31	178	..	3,674	2,211	3,207	..	3,207	3,207	3,207	3,207	3,207	3,207	3,207	3,207	3,207	Canal closed.

NOTE.—The short statement given in the Remarks column shows when river was able to meet indent, and to fill canal and when it ceased to be able to do so. It may be accepted that after dates given in this column there was sample water in the river.

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Mr. F. W. Woods.

[Continued.]

ANNEXURE V.

Statement showing number of wells, etc., on the Western Jumna, Sirhind, Upper Bari Doab and Lower Jhelum Canals.

Canal.	District.	Number of wells.	Average cost of construction per well.	Culturable area commanded by Civil District.	Annual area irrigated by wells.	REMARKS.
1	2	3	4	5	6	7
			Rs.	Acres.	Acres.	
Western Jumna	Karnal	8,076	342	1,721,520	162,459	
	Delhi	7,714	369	291,248	102,616	
	Rohitak	8,240	500	1,337,521	70,750	
	Hissar	355	(a) 1,500	3,163,686	4,917	
	Ambala	4,070	(b) 600 316	873,260	18,609	
	TOTAL	28,449	....	7,387,244	303,351	
Sirhind	Ludhiana	10,311	275—456	816,262	162,286	
	Ferozepore	8,901	400	2,440,506	145,614	
	TOTAL	19,212	....	3,256,768	337,330	
Upper Bari Doab	Gurdaspur	6,566	406	943,046	133,550	
	Amritsar	10,460	175—550	865,133	228,131	
	Lahore	9,485	700	1,515,617	213,012	
	TOTAL	26,542	....	3,323,796	574,696	

Mr. F. W. WOODS, Chief Engineer, Irrigation Works, Punjab.

EXAMINED AT LAHORE, JANUARY 10TH 1918.

Written statement.

VI.—IRRIGATION.

3448. (50) Experience.—I have thirty years' experience of canal construction, irrigation, and irrigation assessment.

3449. (51) Wheat versus cotton.—It is difficult to say what cultivators prefer; but wheat is an easier crop to raise than cotton, and, on the whole, is less liable to damage from insects, and other causes. It is also a food crop and provides the peasant cultivator with daily bread for his own household; whilst cotton has to be sold through a middleman before its value can come into the family purse.

3450. (52) (a) Critical period in regard to water supply.—(a) The critical periods for canal water supply for irrigation are the months of October, November, February and March. Also August. Increase of area under cotton would probably require a corresponding reduction of area under wheat or *toria*, unless canals are enlarged in capacity.

3451. (52) (b) Watering of cotton.—American cotton requires first waterings in March, or before the *Baisakhi* festival which occurs in the second week of April. Cotton receives a depth of four inches or five inches of water at each watering. It is assisted by monsoon rainfall, but the American variety consumes usually a total depth of 24 inches of water, and the *deshi* variety about eighteen inches.

3452. (52) (c) Statistics.—These statistics are recorded in the annual publications of the Irrigation Branch, Public Works Department, Punjab. The figures called for have probably been furnished by other witnesses before the Commission and need not be reported here by me.

3453. (53) (a) Possibility of expansion of area under cotton by enlargement of canals.—We have no reliable statistics of the flow of Punjab rivers in the summer, but roughly I estimate the normal flow of the Chenab and Jhelum rivers to be as stated in my reply to question 55 (paragraph 3457) below. The existing full capacities of the canals dependent on these rivers are as follows:—

Upper Chenab Canal	11,700	cusecs.
Lower Chenab Canal	10,500	"
Lower Jhelum Canal	4,000	"
Upper Jhelum Canal	2,000	cusecs (for irrigation only).

TOTAL 28,200

(2) From the reply to question 55 (paragraph 3457) it may be seen that the combined flow of the Chenab and Jhelum Rivers amounts to from 34,000 to 37,000 cusecs, on the average, throughout March and October; whilst in April and September, it is over 80,000 cusecs. Allowing a reasonable margin for possible error in discharge estimates of the rivers, we could safely add 2,000 cusecs to the capacity of the Lower Jhelum Canal, and the same to that of the Lower Chenab Canal to enable these canals to take better advantage of the river flow in March and October.

(3) The Lower Jhelum Canal is at present being remodelled (*i.e.*, being regraded and elevated and improved in design generally) without increase of its capacity; and this remodelling is estimated to cost about Rs. 25,00,000. It has been estimated that its capacity could be increased by 50 per cent. (*i.e.*, by 2,000

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cusecs) at a further cost of Rs. 15,00,000. The interest charges on this sum, at five per cent. would amount to Rs. 75,000 per annum. This sum could be covered by an increase of 21,000 acres in the annually irrigated area; the average water rate being Rs. 3-8-0 per acre. The average area irrigated by the canal has been 235,000 acres *khari* and 565,000 acres *rabi*; so that an increase of ten per cent. in the *khari* area, or of four per cent. in the *rabi* area would cover the cost of enlarging the capacity of the canal by fifty per cent. (2,000 cusecs). Similarly it might be shown that it would pay to increase the capacity of the Lower Chenab Canal by 25 per cent. (2,500 cusecs).

(4) I am not sure that the enlargement of these canals in capacity would necessarily increase the area of irrigated cotton; since in the past they have not taken full advantage of the ample supplies available in the rivers during March and October. Thus, during the triennium ending 1915-16, the discharges taken by the Lower Chenab and Lower Jhelum Canals averaged as follows during the months of March and October:—

	LOWER CHENAB.		LOWER JHELM.	
	March.	October.	March.	October.
1913-14	7,500	9,017	3,530	3,511
1914-15	7,720	9,831	3,384	3,542
1915-16	7,873	9,471	3,571	3,757
AVERAGES	7,731	9,440	3,496	3,603

(5) The full capacity of the Lower Chenab Canal being 10,500 cusecs, and that of the Lower Jhelum 4,000, it can be seen that in the month of March, at least, they have not, in the past, taken sufficient advantage of the supplies available in the rivers. I feel sure however that the cost of the increase of the capacity of each of these canals by 2,000 cusecs in each case would be recouped by an increase of irrigated area either of *khari* or of *rabi*. It is by no means certain that the cultivators would increase their area under cotton rather than under wheat, though of course they *might* do so.

3151. (54) (a) Improvement in duty of water by remodelling of outlets.—Equalizing the distribution of the supply of canal water between the upper and lower reaches, respectively, of distributaries, is not likely to improve appreciably the "duty" of the unit of water supply. Such equalization is necessary from considerations of equity towards the irrigating public in general; but improved duty cannot, in theory, be expected therefrom. *Ceteris paribus*, the best duty should be obtained by delivering the canal supply on the nearest fields, and the worst by carrying it on to the greatest distance from the head of the distributary. But if it be argued that to deliver an abundance of it at the nearest points is likely to lead to wasteful consumption there, it must also be conceded that a scantiness of it at more distant places will lead to greater economy of consumption in those places. Hence the net result, in theory, must be the same from the point of view of the argument suggested.

3455. (54) (b) Utilization of modules.—Modules if efficient would serve to equalize the distribution of supply by preventing outlets in the upper reaches of distributaries where the water levels are relatively highest, and where they have a tendency to rise above design by reason of silt deposits in the channel, from drawing off an excessive share of supply through the excessive head of water pressure on them.

3456. (54) (c) Effect of remodelling of outlets on irrigated area.—Equalization of distribution will and increase the irrigable area.

3457. (55) Fluctuations in river supplies and their effects.—We do not possess reliable statistics of the volume of flow in Punjab rivers during the summer, but the figures subjoined give approximately the average daily discharge of the Chenab and Jhelum rivers, month by month, on the average of the quinquennium ending 1915-16:—

Month.	RIVER.		Combined Chenab and Jhelum.
	Chenab.	Jhelum.	
January	10,000	11,000	21,000
February	11,000	12,000	23,000
March	16,000	18,000	34,000
April	41,000	45,000	86,000
May	66,000	70,000	136,000
June . . . . .	.....	.....	.....
July . . . . .	.....	.....	.....
August	65,000	69,000	134,000
September	41,000	42,000	83,000
October	18,000	10,000	28,000
November	10,000	13,000	23,000
December	8,000	10,000	18,000

The flow is at a minimum in December but rises gradually through January, February, and so on till it reaches a maximum in June; after which it diminishes regularly from August to December. This is on the supposition that we ignore high floods, which are of short duration. The flow in December is nearly equal to that of January; that of February and November are about the same. The March and October flow are about equal to each other, as also that of April and September, whilst the flow is fairly the same from May to August inclusive. See also my reply to question 53 (paragraph 3453) above.

3458. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—In cases in which canals carry a supply for irrigation during the summer months only, it would be possible for the sowings and fine waterings of cotton to be carried out by irrigation from wells if the wells were sufficiently numerous. But

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an ordinary well, worked with bullock power and Persian wheel, could not give final waterings to more than about twenty acres of cotton. Maturing of cotton irrigation could be done anywhere in riverain lands where the spring level is not more than 25 feet below ground surface.

3459. (56) (b) I have endeavoured to obtain statistical information on this point, but have not obtained it yet. In the riverain tracts of the Jhelum river in the Shahpur District, there appears to be, on the whole about one well to every 25 acres of land, but the wells are clustered together more closely along the river margin than at some distance (even two or three miles only) from it.

3460. (56) (c) Tube wells.—I have little personal experience of the working of tube-wells, but I doubt whether they would work well without expert supervision in rural areas.

3461. (56) (d) and (e) Construction of weirs *versus* construction of wells.—If by this question be meant the linking on of inundation canals to the perennial canal system, I am not in favour of it; nor am I in favour of discouraging irrigation from wells.

3462. (57) Effect of enlargement of canals on revenue.—If the capacity of the Lower Jhelum Canal were increased by 2,000 cusecs, i.e., from its present capacity of 4,000 cusecs to one of 6,000 cusecs, it could irrigate with that extra supply, at the rate of four acres per cusec per *diem*, flowing for forty days (1st March to 10th April) 320,000 acres. I do not for a moment suggest however that any such result would follow from such an increase in the capacity of this canal. The extra water supply might be available, but it does not follow that the cultivators would avail themselves of it for the irrigation of cotton or of any other crop. It would not be safe to rely on paper estimates of the addition to gross revenue obtainable from an increase of capacity of the Canal. I would not say more than that the revenue derivable from the operation would probably fully justify the expenditure involved.

3463. (58) Cropping and canes affecting it.—The cropping on a holding of 100 acres is roughly as follows. Wheat 40; cotton 20; toria 20; *juar-chari* 12; *makki-bajra* 4; miscellaneous 4. The millets are grown from agricultural necessity, for the feed of oxen. Toria pays the *kharij* rents. Increase of cotton area might have the effect of reducing wheat area through labour difficulties, even if the canals were enlarged, in the absence of labour-saving machinery.

3464. (59) Practicability of lining canals.—I do not regard the waterproofing lining of Punjab Canals as being either practicable or necessary.

3465. (60) Cost of lining canals.—To line the Main Line of the Lower Chenab Canal and its Upper Jhang and Upper Gugera Branches with clay puddle would cost at least Rs. 76,00,000. To line it with cement plaster one inch thick would cost over Rs. 2,53,00,000. And engineering estimates of this sort are easily exceeded by actual expenditure in practice. The total capital expenditure on the Lower Chenab Canal down to end of 1915-16 was for "Works" about Rs. 2,52,00,000.

3466. (61) Enlargement and lining of canals.—The lining of a canal with waterproof material might interfere with its subsequent enlargement, if the enlargement involved increase of depth; otherwise it would affect only the lining of the sides of the channel. Enlargement of a flowing canal could best be done by steam navvies working on the sides of the canal along a line of rails laid on the banks.

3467. (62) Effect of lining canals on seepage problems.—The lining, if effective, would reduce the percolation from the canal, and retard if not prevent the rise of the sub-soil water table. But it would always be a matter of doubt whether any given kind of lining would be effective; it would depend so much on quality of material, workmanship, etc. And its efficiency could not be practically tested till after great expenditure had been incurred. And even if effective it would be quite as likely to be harmful, as otherwise. The rise of the sub-soil water table is not *per se* objectionable; whilst a low sub-soil water-table is objectionable. Stagnation, alone, of sub-soil water is objectionable, and that can be prevented by drainage.

3468. (63) Effect of lining canals on supplies.—The waterproof lining of the Main Line of the Lower Chenab Canal and of its Upper Jhang and Upper Gugera Branches would add about eight per cent to the discharge of the canal in either summer or winter season. The expenditure involved would not be justified by the saving of water effected nor by other consideration.

Mr. W. F. HOLMS and Mr. F. W. WOODS called and examined.

3469. (President.) Mr. Woods.—My charge consists of all canals lying to the North West of the Ravi as well as the Lower Bari Doab Canal on the South and East side of that river. The canals on the South-East of the Ravi are under Mr. Holms, who also has charge of the Derajat Circle.

3470. Mr. Holms.—As regards the Sutlej Valley project, it will give new perennial irrigation to the north west corner of Bikaner, to parts of Bahawalpur State and the Nili Bar in British territory and at the same time irrigate the land now served by the Sutlej Inundation and Bahawalpur Chenab Inundation Canals. The project provides for two weirs, one near Ferozepore and the other about 120 miles further down the river. It is still under the consideration of the Government of India. I fancy that it is held up for political reasons. As to the provision for weirs for irrigation in the Montgomery and Multan districts, I would mention that included in my various projects is provision for four weirs, three on the Sutlej and one on the Chenab just below its junction with the Jhelum. Of these, two weirs are included in the Sutlej Valley project, a third weir further up the river is part of the Bhakra Dam scheme which is under preparation and is a very big canal project. The fourth weir is on the Chenab and forms part of the Haveli project which has come back from the Government of India for revision.

3471. As regards the prospects of American cotton in the Eastern Punjab tract, there is a fair area or *deshi* cotton under the Western Jumna Canal. The Sirhind Canal tract is very unsuitable for cotton and only a very small percentage of the area under it is cultivated with that crop. In the middle Punjab, there is a fairly large area of cotton under the Upper Bari Doab Canal and there is no possibility of extension. The intensity of irrigation in this tract is very high probably from seventy to eighty per cent. over the whole tract. Cotton is not always secure in the Eastern Punjab as was made clear by this year's experience. We had a very unseasonable and heavy downpour on the 25th and 26th October following heavy rain towards the end of September. The result was that the outturn of cotton was very poor and very big remissions had to be given. The Eastern Punjab is served by the Western Jumna Canal, and the Jumna is not typical of the Punjab rivers. It is not so much snow-fed as the others and in consequence it rises six weeks to two months later. The more northern rivers rise by the 1st week of April. Water is therefore very short in the Western Jumna Canal tract in the early part of the *kharij* seasons which makes the cotton crop rather precarious. It would certainly be a good thing if the Agricultural Department could find some new variety

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[Continued.]

of cotton or other new crop adapted to the conditions which prevail. That especially applies to the Sirhind Canal. In that case there is plenty of water in the *kharij* and plenty of land but the people are not very energetic.

3472. As to the view expressed in the last paragraph of my written evidence, (paragraph 3447) I would explain what was in my mind was that, naturally enough, the first projects to be taken up in any province are the easiest. The land irrigated is probably the land near to the source of supply and the other conditions are favourable. Naturally, in the course of events, the more difficult and expensive projects tend to come later. The same water rates which might be sufficient in the case of the earlier projects to put them on a sound financial basis and to enable them to be readily classified as productive works, under the definition laid down by Government, would not necessarily be sufficient in the case of the more difficult projects and it is very often on the financial prospects that the sanction for a big project is readily accepted or considerably delayed. Apart from that, higher water rates facilitate the working out of the designs very much, as one is not hampered by an excessive regard to cost. The project I had in mind was the Bhakra Dam project that we are now taking up. The older canals with weirs are comparatively easy in design and construction; all of them are served by simple weirs and the canal gets straight on to the land irrigated and may begin to irrigate within ten or twenty miles of the weir. In the Bhakra Dam project, instead of having a simple weir, we will have a dam in low foothills over 300 feet high. The water will have to travel over a hundred miles, before it even begins to irrigate. So obviously the conditions are much less favourable.

3473. Mr. Woods.—As to the area likely to come under cotton if the Sind Sagar project comes into existence, the project has not been worked out yet. The annual irrigable area will probably be about a million and a half acres. Out of that, perhaps half a million acres would be irrigated in the *kharij* season, of which we might expect from 100,000 to 200,000 acres of cotton. The project has not actually reached the Chief Engineer yet.

3474. Mr. Holms.—The Haveli project merely affects the inundation canals in the Multan and Jhang districts. As to the area that might come under cotton in the tract commanded by it, it is proposed to bring under new irrigation about 370,000 acres of which presumably about half would be *rabi* and half *kharij*, and 40,000 acres might be cotton. In preparing a project, we estimate the area that will come under *kharij* and under *rabi* respectively. We do not estimate the various crops in detail, i.e., we should not estimate the possible area that would come under cotton. In the case of the Haveli project, it will irrigate about 60 per cent. of the total area as against 47 at present. These figures have been worked out not with reference to waterlogging but with reference to the supply of water available. The supply available throughout the *kharij* is not unlimited. I fancy that, in fixing the percentage I have mentioned, the aim was to get an all round increase suitable to the conditions within reasonable limits. Water logging is a local problem rather than a general one in the Punjab. It is more marked in certain localities.

3475. (Mr. Roberts.) The Haveli project will take up the whole area irrigated by the Sidhnai Canal which now grows *deshi* cotton. The whole of the area under the Sidhnai which was formerly irrigated by water from the Ravi will be irrigated by combined water from the Jhelum and the Chenab. It is hoped to improve conditions on the Sidhnai and all this tract should be suitable for American cotton as far as water supply is concerned. The total area under irrigation would be nearly seven lakhs of which 3.7 lakhs would be new irrigation. In 1915-16, the Sidhnai matured 223,000 acres out of 270,000 acres annual irrigation; of which 22,000 acres of cotton was matured which is ten per cent. It could do a larger percentage of cotton with a more assured supply of water early in the season. The Upper and the Lower Sutlej Canals, with the other inundation canals in the Derajat Circle, matured in 1915-16 1,200,000 acres of irrigation. The cotton area matured was only 54,000 acres which is four and a half per cent. of the matured area. But these inundation canals are very unsuitable for cotton even for *deshi* cotton, as they open so late. Cotton on the Sidhnai went down very badly in 1916-17. The cotton area must be small as long as the inundation canals continue to open late. The percentage of the area under cotton on the Sidhnai is generally about ten but if the river is favourable may rise to fifteen. The Sidhnai is not an inundation canal strictly speaking. Inundation canals are canals which entirely depend on the natural rise of the river. The Sidhnai has a dam. There has been some good American cotton on the Sidhnai. The Sidhnai under new conditions might easily work up to twenty per cent of cotton.

3476. There are projects for three weirs which would help inundation canals. Of these three, one is included in the Haveli project with which we have already dealt. The Sutlej Valley project includes provision for two weirs, one weir at Ganda Singhwala about four miles from Ferozepore and the other about 12 miles further down the river near the railway station of Jamra. The total new irrigation under the project is estimated at 16½ lakhs of acres, i.e., roughly about a million and a half acres. Of the 16½ lakhs of acres, 11.7 lakhs will be new perennial and the remainder irrigation will be new irrigation in the *khadir*, which may or may not be suitable for cotton. No estimate has been made of the areas under the different crops classified into *kharij* and *rabi* except to the extent that the rates of assessment on which we base all these projects have to go to the Financial Commissioner and the Revenue authorities for consideration and determination and when they give us the rates we can apply them to the projects. The rates are fixed by the Financial Commissioner. In fixing the rates, the Financial Commissioner is no doubt guided in a general way by the probabilities of the various crops that are likely to be grown but all we are told is that we may base our financial returns on certain rates per acre irrigated. As to the crops that are to be grown, I do not think that the Financial Commissioner can do more than say that on such and such soil only certain crop would be likely to be grown. He could only give an answer in very general terms.

3477. Mr. Woods.—We go merely on *kharij* and *rabi*. We know the duties for *kharij* and *rabi* but not those for a particular crop. Our rates are not uniform for all crops. The point which interests the Committee is the possible area under contemplation for American cotton, but we have not in the past designed our canals for the irrigation of particular crops. We merely have figures which show that with given volumes of water such and such areas will be irrigated in the *kharij* and *rabi* seasons respectively. You may calculate that a certain percentage of the *kharij* area will be under cotton, and thus arrive at the results you aim at. If the Agricultural Department can estimate the percentage of the *kharij* area which will be under cotton, it will know also the cotton area.

3478. Mr. Holms.—The Bhakra Dam project contemplates a million and a half acres of new irrigation. The irrigation under this project will be in the South Eastern Punjab.

3479. (Mr. Ashton.) Mr. Woods.—There is a lot of water available in the Punjab rivers except the Jumna in April and May for the extension of *kharij* cultivation. The demand in April and May is not up to the full capacity of the canals. In April especially, the demand is slack and from our point of view, i.e., that

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[Continued.]

of running the canal efficiently, it would be better to have a keener demand. It would mean so much more revenue coming into our pockets. Just at present cotton is doing better than wheat and it is likely that the cultivators will go in for cotton, at any rate for the next few years, on account of the present high prices. As for as we are concerned, we should be glad to have a better supply running in the canals in April, May and June. We have got the establishment to deal with it.

3400. (Mr. Roberts.) Mr. Woods.—In regard to the Lower Jhelum Canal, I proposed some years ago to increase the *kharij* capacity of the canal for which there is ample water available from April to October. I am not in a position to predict whether this increase of capacity would result in an increase under cotton. There may be an increase under cotton: it is quite likely, but one cannot confidently predict that result. It would depend largely on the *zamindar* who is actuated by economic considerations and is affected by questions of price. He might prefer to go in for sugarcane or for rice. The proposed increase of capacity would enable us to distribute the *rabi* supplies more efficiently in connection with the Triple Canal system. It would facilitate the distribution of supply and bring this canal more in line with others in the time ratio of rotational flow, supposing that none of the present *rabi* supply is taken away from the Lower Jhelum.

3481. I do not think that there is any danger of the percentage of the culturable commanded area irrigated annually becoming too high. At present it is from 75 per cent. to cent per cent. per annum. I do not think there would be any harm in cent. per cent. irrigation per annum including *dofasli*. Many distributaries actually do at present irrigate over 100 per cent. of their culturable area annually. The percentage in the case of every orchard and garden goes up to 200. So far as my experience goes, I do not think that there is much danger from the soil point of view, from excessive cropping. But I am not an expert on that. If it does not do harm to orchards and gardens, I do not understand why it should do harm to other crops. Of course the question of manure has to be considered. If you crop heavily, you will have to put on more manure. If you have a high intensity, you will be forced to grow short season leguminous crops.

3482. (Mr. Henderson.) I do not think that there is anything in the idea that future projects in the Punjab will affect the water supply available in Sind. The amount we might take from the summer flow of the rivers would be comparatively insignificant in comparison with the summer flow of the Indus river where it enters Sind. I do not think the winter flow would be affected after a certain space of time because as our canals develop and the subsoil water table fills up, there will be percolation going back into the river. The Sukkur Barrage would not affect us in any way.

Mr. MIR MOWAHID HUSSAIN, Deputy Collector, Lower Chenab Canal, Lyallpur.

EXAMINED AT LYALLPUR, JANUARY 12TH 1918.

Written statement.

(Translation.)

I.—AGRICULTURAL EXPERIENCE.

(a) "Deshi" short staple cotton.

3483. (1) Experience.—I have been stationed at Lahore, Amritsar, Patiala, Nabha and Faridkot States, Ferozepore, Dera Ghazi Khan, Multan and Lyallpur on Government duty and as I have some interest in Montgomery district and Bijnor district in the United Provinces, I could find occasion to talk with great interest to cultivators on cultivation and marked carefully the way in which they cultivated. It is a long time since I left the above-mentioned districts and therefore I cannot claim to be in a position to discuss the methods of their cultivation. However, as I have been in the Lyallpur district for the last five years and although I could not find occasion to make experiments on any plot personally, I have gathered some information by questioning the cultivators whilst out on tour in view of which I give the following answers.

3484. (2) Varieties.—With the exception of the Lyallpur district all the other districts grow *deshi kapas*, i.e., red-flowered (*rarar*), yellow-flowered and white-flowered (*tillar*). The latter has a broader leaf than the first and second varieties and is more segmented. It has also a longer staple, and is distinguished by its short and spreading plant. Of these varieties, the *tillar kapas* which contains one-third cotton and two-thirds seed, has been considered most desirable. *Narma*—probably a foreign *kapas*—has also been found to grow in small quantity in the Lyallpur and Multan districts. In the Lyallpur district, attention has been paid to the encouragement of the cultivation of American *kapas* for the last two years.

3485. (3) Size of holdings.—The average size of the holding under *kapas*, except in the new colonies, cannot be estimated. Every cultivator according to the scale of his holding prepares a certain portion of his land for the cultivation of cotton. In the new colonies, the average size of the holding can be reckoned as one square. In the old colonies, one plough is held to cultivate twenty acres which can be called a holding. In every old holding, three *killas* of land per holding is put under cotton cultivation. In Montgomery and Multan districts, the land is being served by inundation canals, which can supply sufficient water for cotton cultivation. The average holding cannot correctly be estimated in these districts, but in view of the fact that the *kapas* is considered a profitable crop it may be estimated as five or six *killas*.

3486. (4) Yields and profits.—The average outturn of *deshi kapas* in the Montgomery and Multan districts is from seven to eight maunds per acre and even more, if the season is favourable, while that of Lyallpur district is found to be five maunds, but for the last two years it has yielded only two maunds on account of the unfavourable climatic conditions.

3487. (5) Rotations and manures.—The land for cotton cultivation is prepared by ploughing repeatedly three or four times, and no manure is applied. The general rotations followed are wheat, cotton, and *toria*. The rotten roots and remains of the former crop act as a manure to some extent. If the rainfall does not exceed the normal, the crop sown after wheat gives good results otherwise the one after *toria*.

3488. (6) Comparative returns.—As the cultivation and the picking of both short and long staple cotton are done mixed together, no separate accurate estimate of outturn can be made for the different varieties but it has been observed that the outturn of cotton from *tillar* is one-third or a seer or two more, and of seed two-thirds or a seer or two less and that the other varieties yield a seer or two less than even the one-third.

3489. (7) Conditions affecting increase in area.—The cultivators usually decrease or increase the area under cotton according to their profit or loss. When the produce in a certain year is less on account

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of some earthly or heavenly calamity or the price goes down, the cultivation in the following year is decreased but it is not based on any principle. If the prices are fairly fixed and the demand increases, there is a possibility of an increase in the area under cotton by one-fourth or one-half of the present crop.

3490. (8) Uses of seed and seed selection.—The seed is used as fodder for milch cattle, because it adds fat to their milk. The cultivators specially select big, healthy and bluish seed for sowing purposes and particularly prefer to have hand ginned seed, for the edges of such seed are not destroyed and some cotton is also left on it, which enables it to germinate properly.

3491. (9) General economic conditions.—No other improvement except that weeding should be done by ploughs, a practice already adopted by some cultivators, can be suggested. If the good and healthy seed from the first or second pickings were selected for sowing, there would, I think, be some saving in the pickings, for, if the seed of one and the same picking, instead of the different pickings, is sown, its plant will require one or two pickings only and not several.

(b) "*Deshi*" long staple cotton.

3492. (15) Conditions affecting increase in area.—The increase in the area under *deshi* cotton in competition with food crops is an impossibility. It requires more labour, more expenditure and it has also proved fruitless to grow anything but fodder crop in the area after *kapas*. The cultivation of *kapas* can be increased, if its price should rise so very high as to cover the expected profits of both the *rabi* and *kharif*.

3493. (16) Suitability of existing varieties.—As the produce of the old yellow *deshi kapas* has very much decreased for the last few years, the cultivators are tending towards the cultivation of the American or *tillar kapas*. Their liking for the American is so keen that it is easy, with a little effort, to replace the yellow *kapas* by the American in the Lyellpur colony.

3494. (17) Prevention of mixing of different varieties.—The seed of the long and short staple cotton can be separated only in the field. It is difficult to do so in the factory. The easiest way to do this would be to tempt the pickers by offering a higher proportion of long staple cotton as compensation for their labour.

(c) *Exotic* cotton.

3495. (28) Importation of seed.—If a good seed of long staple cotton be imported, even at a price higher by one-fourth, from America or Egypt, instead of selecting it in this country, the cultivators might prefer to have that. The cultivators grow American or *narma* simply for getting higher prices, otherwise its picking is more difficult than *deshi* and the second picking unlike the first is to be separated from the boll and thus takes more time in gathering. *Deshi* can be ginned and spun easily, but this is not the case with the foreign *kapas*, because the machines and implements of this country cannot deal with its fine and subtle fibres.

VI.—IRRIGATION.

3496. (51) Wheat *versus* cotton.—Wheat cultivation is preferred to cotton because (1), there are greater facilities for sowing, ploughing, weeding, etc., (2) there is less anxiety in regard to watering, (3) the area for its cultivation becomes easily cultivable, (4) it is in great demand for personal consumption, (5) it requires little space for storage and (6) it is easily guarded in the field as well as in the house. None of the above mentioned facilities is found in cotton but quite otherwise. Loss in the field, strict supervision at the time of picking, want of spacious accommodation for its storage in the house, fear of insects, rats, damp alteration in rates, boll-worm, storm, excess of rain and continuous fear during the rainy season are all serious anxieties that harass the poor cultivator; for instance the produce of this year in spite of plenty of rain and irrigation has been reduced to less than one-half of the previous years', whereas wheat is not liable to such losses.

3497. (52) (a) Critical period in regard to water supply.—The critical period in regard to the water-supply is the beginning of April and the end of September. The end of September and the beginning of October are dangerous days on the *pukka canals*. The crop sown late, on account of the inability to get water in April, produces a less number of bolls, because it also gets less water in September and October.

3498. (52) (b) Watering of cotton.—At the beginning of the cultivation of *deshi* cotton, the first watering is given after one and a half to two months because so long as the plant is not sufficiently strong it is thought objectionable to water it. Afterwards one watering per month is given up to the end of October. On the inundation canals, watering is stopped in September because the supply of the canal itself is stopped. *Deshi* cotton requires four waterings and American five in all.

3499. (53) (a) Possibility of expansion of area under cotton by enlargement of canals.—The increase in the supply and the expansion of the canals are not sufficient to encourage the cultivation of cotton unless the cultivators have some special temptation.

3500. (54) Improvement in duty of water by remodelling of outlets.—The equalisation of the distribution of the water-supply between the upper and the lower outlets on the distributaries or the fixing of appropriate modules will undoubtedly increase the total irrigation by one-fourth but even in that case there is certainty of the extension of wheat area, as can be seen from the fact that, if the cultivator got more water in *kharif*, he, according to his own principle, ordinarily sows sugarcane, cotton, maize and fodder but would not increase the area under cotton. The only solution of the problem for the encouragement of the cultivation of cotton lies in the direction of facilitating the cultivators to obtain good seed and good rates; because they act only on the principle that they would increase the area under cotton when they could see the profit fetched by the last year's crop. However, if the outlets were enlarged, a liberal supply were available in September and October, and the modules also were allowed to share this supply, the water should be so much increased that it should be sufficient both for *rabi* and *kharif* and at the same time the cultivators should be convinced that the extension of the area under cotton is sure to lead them to a profit. Then there would be a probability of an increase of about fifteen per cent. If, by chance, the direction of the river is changed or the inundation canals are blocked in the Montgomery division in the beginning of September, the cultivators often give one watering from wells, which they then repair. If the canals were so arranged as to suit both the *rabi* and *kharif* crops, the irrigation from wells could be stopped, and most of the area could be irrigated by canals. One well cannot irrigate more than twenty or twenty two *ghumauns* and it is rather troublesome and expensive to irrigate from wells. Most of the land cultivated by *zamindars* is unirrigated because of their limited means and of the constant repairs of their wells and other materials. The *zamindars* of Montgomery are fond of cultivating *tillar deshi* cotton,

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3501. (58) Cropping and causes affecting it.—If a holding is taken as of 100 acres and sufficient water is given, the cultivation will be done in the following proportions :—

Wheat.	Toria.	Sanji (fodder).	Cotton.	Maize.	Sugarcane.	Kharif fodder.
44	12	8	12	8	4	12

3502. (64) Suitability of water rates.—The present water rates cannot stop the cultivator from sowing crops according to his own needs, because the cultivation of each and every crop which he does is in accordance with his needs, labour expenses, care, rate and season. However, if the water-rates on cotton were reduced to some extent, there might be some increase in the cotton area.

Mr. MR. MOWAHID HUSSAIN called and examined.

(Translation.)

3503. (President.) I have 29 years' service : about twenty years as *zilladar* and the remainder as Deputy Collector. I have been on the Sirhind Canal, Upper Bari Doab Canal, in the Derajat Circle and lastly on the Lower Chenab Canal. I own land in the United Provinces. The regulation of canal supply in the *kharif* is done according to the *zamindari* demand. The *zilladar* gives indents for each channel to the Sub-Divisional Officer who indents for supply. Under present conditions of cultivation, if a full supply were run during April, May, June and July, damage would occur at the tails of channels by too much water getting in. Regulation would be easier if the demand during *kharif* was keener than it is now. The *zamindars* do not clear their water courses from silt so frequently or keep them in such good order during the period from May to August as they do it in the *rabi*. They start hard work on their water courses in September. If the water courses were kept from May to August as clean as they are in *rabi*, the outlets would draw more water. During *kharif* up to September, the *zamindars'* demand for water is not so keen as it is after the beginning of September and during the *rabi*. Hence the *zamindars* do not keep their water courses as clean during *kharif* as they do in the *rabi* on the Upper and Lower Sutlej canals.

3504. I have seen that the cultivators do not sow their cotton with well water. They delay their cotton sowings until the canals come into flow. If the canals close early, they mature their cotton on well water but only such fields as are near the wells. Final watering is essential in March for the ripening of *rabi* crops and the cultivation of ordinary *kharif* by wells is difficult. April and May are very hot months and to work on wells for the extraction of necessary water is very toilsome during these months both for men and bullocks. In the Upper Sutlej Canal district, where I own land, the *zamindars* give a final watering to wheat from wells in February and sometimes early in March. The well irrigated wheat requires four or five waterings to mature, i.e., the sowing in *Kartik* (October-November), the first watering in *Posh* (December-January), the second watering in *Magh* (January-February), the third in *Phagoon* (February-March) and the fourth and sometimes the fifth in *Chait* (March-April). From the end of the month the working of the wells ceases. Even though after the beginning of March, water is not required for *rabi*, the *zamindars* on the Upper Sutlej do not use their wells to start *kharif*, though wheat harvesting does not come on till about the 12th of April or later. In the Derajat Circle, there is ample water in wells but in the Upper Sutlej inundation canals tract, water in the wells is somewhat scanty. Two waterings are given to wheat during March usually from wells and the well water supply up to the end of March is taken up for the maturing of wheat. The harvesting of wheat starts about the 12th April but before this the harvesting of gram, barley and mustard seed is done, so that the *zamindars* stop their wells at the end of March, and after that full attention is given to harvesting operations. In view of the high prices obtaining at present, I think the *zamindars* could increase their area under cotton by one or two *killas* per square but not more than this.

3505. In suggesting in my written evidence that outlets should be enlarged for an increased supply in September and October, my idea is that the supply of water both for *kharif* and *rabi* in the canals should be increased in such a way that the enlargement of outlets should not prove harmful to any of the two crops. But if you enlarge them during *kharif*, when there is abundance of water, and reduce them during *rabi*, when there is scarcity of water in the canals, the *zamindars* will be disheartened, because they do not like to lose their *rabi* crop by extending the *kharif*. My written evidence explains everything in detail.

3506. The present water rate for cotton is Rs. 3-12 including land revenue, etc. *Zamindars* pay about Rs. 9 an acre on cotton. I consider that if the market rates for cotton were to go down seriously but the water rates were reduced to say Rs. 2, it might have the effect of keeping up the area under cotton. At the present water rates, a reduction in the water rate would not have any effect.

3507. (Mr. Roberts.) On the Upper Sutlej, it is common to give four or five waterings to wheat after sowing. My lands are on Upper Sutlej. I am a native of Bijnor in the United Provinces. I have also got some land in the Montgomery district and in Bijnor.

Sardar Sahib CHAUDHARI AMIR SINGH, Deputy Collector, Lyallpur Division.

EXAMINED AT LYALLPUR, JANUARY 12TH 1918.

Written statement.

(Translation.)

V.—GENERAL.

3508. (47) Effect of water rates.—The water-rates and the land cess have both a great effect on the cultivators and land-owners' preference for a particular crop, for they keep the expenditure as well as the income of the cultivation in view. Excepting a little fodder crop, essential for the feed of their cattle they evidently give preference to the crop fetching comparatively a better price.

3509. (48) Desirability of alteration in water rates.—There is a general complaint about the high water-rates charged for maize and gram but the latter appears to be baseless and if the maize rates were reduced from fourth to fifth grade, i.e., from Rs. 3-12-0 to 2-8-0 an acre, there is a possibility of an increase

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[Continued.]

of its cultivation. Although maize is not exported from India, because it is cheaper than wheat, the cultivators prefer it to wheat for their food. The increase in the production of maize will therefore mean less consumption of wheat in India and more wheat available for export from the country.

VI.—IRRIGATION.

3510. (50) Experience.—I have been employed in the Canal service since 1887, and have all along been put on the irrigation work. I have been doing the irrigation assessment work for more than twenty years.

3511. (51) Cotton *versus* wheat.—The rate of cotton for the period of last eight years has been low, and this can be justified by the statements appended. The landowners as well as the tenants are as a rule desirous of growing the crop that fetches more money, as explained in answer paragraph 3508 above: consequently prior to the year 1916, when they could see a loss rather than a profit they preferred to grow wheat to cotton, but since 1916 the rate of *kapas* has gone high and the *zamindars* are giving preference to this crop.

(2) The cotton plant on account of its fragility and its inability to withstand heat gets damaged if a second watering after fifteen or twenty days from the first watering were not given. On the contrary, neither does wheat require water so early nor is its plant so fragile as to get injured so easily: this is why the landowners and the cultivators prefer to sow wheat rather than cotton. But, if in the beginning of April, when the necessity for watering *rabi* decreases, the cotton cultivation is commenced (and finished within the same month) and the canal water-supply is kept continuous, i.e., the supply of water is not reduced, during the months of April, May and June, when there is plenty of water in the Jhelum and Chonab rivers, then the danger of damage to cotton on account of the scarcity of water, can be possibly avoided.

3512. (52) (a) Critical period in regard to water supply.—The critical period for the water supply is the whole of the months of March and September, and if the cultivation of cotton is increased, the present defective system of canal water supply during the summer season is liable to injure the *kharij* cultivation. But if the cultivation of cotton be commenced in the beginning and finished at the end of April and the necessary supply of canal water is maintained during the months of April, May and June, the *kharij* crop can be expected to give good results, provided the weather remains suitable (in spite of there being an increase in the cultivation of cotton).

3513. (52) (b) Watering of cotton.—Cotton cultivation requires water from the beginning to the end of April and late-sowing of cotton continues up to the month of May. The cotton crop requires its first watering after about four or six weeks and after that the crop is watered on every turn which falls between ten to twenty days. *Deshi* cotton requires one watering in October also. The quantity of water, which can irrigate three *killas* of *kor* land for the cultivation of cotton at the first instance, is enough to irrigate four *kilas* of cotton land afterwards.

3514. (54) (c) Effect of remodelling of outlets on irrigated area.—There is a probability of an increase of about one quarter of the whole of the irrigated *kharij* crop, if the distribution were equalized. The principal *kharij* crops which bring the best return are sugarcane, rice, cotton and maize but of these sugarcane and rice require more labour, the rate for maize is cheap, but the water taxes are comparatively high and the cultivators therefore pay little heed to this crop (maize). Thus it seems that cotton will be the only suitable *kharij* crop.

3515. (55) Fluctuations in river supplies and their effects.—There is generally a gradual increase of water in spring and a gradual decrease in autumn in Jhelum and Chonab rivers and sometimes there is an extraordinary decrease of water in the above rivers during August and September but such decrease is very seldom and therefore the cultivators have a tendency to grow cotton.

3516. (56) Utilization of wells for irrigation of cotton in canal areas.—In cases in which the canals run only in summer, the cotton crop is irrigated firstly by canal-water and when there is no water in canals the final watering is done by wells. This kind of mixed irrigation exists in the Shahpur Canal Division. Although the area under cotton in the villages of Hafizabad Division in Gujranwala District is small and the need for irrigation for the cultivation of cotton on account of the nearness of the "spring level" is not great, yet sometimes the canal irrigated *kharij* crops have to be saved by the irrigation from wells.

3517. (58) Cropping and causes affecting it.—The following results have been obtained from 100 acres of *kharij* land in the Lyallpur Division by taking it for the past seven years, from *kharij* 1910 to *kharij* 1916:—

Kharij.							
Sugarcane.	Rice.	Cotton.	Indigo.	Maize.	Juar.	Miscellaneous.	Total acres.
2.3	0.2	8.5	...	4.7	8.8	4.5	20.0
Rabi.							
Toria.	Wheat.	Barley.	Berara.	Gram.	Senji.	Miscellaneous.	Total.
11.7	45.5	0.6	0.1	4.5	4.9	1.5	68.8
							97.8

ANNEXURE I.

Statement of cereals in the Lyallpur Division arranged according to the land and water-tax.

Land-tax.	WATER-TAX.					
	First grade @ Rs. 7-8-0 per acre.	Second grade @ Rs. 6-4-0 per acre.	Third grade @ Rs. 5 per acre.	Fourth grade @ Rs. 3-12-0 per acre.	Fifth grade @ Rs. 2-8-0 per acre.	Sixth grade @ Rs. 1-4-0 per acre.
At least As. 12 per acre.	Sugarcane, <i>Kauldoda</i> , <i>Singharra</i> .	<i>Munji</i> .	Gardens, vegetables, medicines, spices, melons and water melons.	Wheat, barley, <i>berara</i> , <i>toria</i> , <i>alsi</i> , <i>taramira</i> , <i>kusina</i> , cotton, maize, <i>sun</i> , <i>sarkanda</i> , <i>senji</i> , <i>methra</i> , <i>mena</i> , <i>fuson</i> — <i>rabi</i> , <i>mehndi</i> and <i>til</i> .	Gram, <i>musur</i> , <i>fuson</i> — <i>kharij</i> , <i>moth</i> , <i>chari</i> , <i>gicara</i> , <i>bajra</i> , <i>munji</i> , <i>lagani</i> , <i>swank chinda</i> and <i>madahi</i> .	Cotton of the previous crops. Self-grown grass.
At the utmost As. 10 per acre.						

NOTE.—*Jhalari* land is charged at one half the total water-rate on the newly cultivated land.

Punjab.]

Sardar Sahib CHAUDHARI AMR SINGH.

[Continued.]

ANNEXURE II.

Statement showing yields and prices of crops.

Name of crop ¹	AVERAGE PRODUCE AT THE END OF SETTLEMENT.		AVERAGE RATE PER RUPEE (IN SEERS).										REMARKS.
	Rakh ¹ Branch.	Jhang Branch.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1916.	1917.	
	Maunds	per acre.											
Black sugar	18	14	10½	10½	10½	7½	10½	11½	10½	7½	8½	10½	
Cotton	4	4	7	5½	4½	5½	4½	5½	10½	5½	4½	2	
Maize	13	10	15½	23½	26½	20½	16	19½	13½	15½	14½	19	
Juar	7	6	15½	21½	23½	16½	10½	17	12	13½	13½	..	
Bajra	7	7	12½	20	17½	17½	15½	18	11	12½	13½	..	
Wheat	13	10½	..	11½	14½	..	13½	13½	13½	11½	13½	10½	
Toria	7½	5	..	6	10½	..	7½	7½	10½	8½	6½	10½	
Gram	0	8	..	17½	21½	..	16½	16	11½	14½	12½	12½	
Barley	13	10½	..	..	..	..	..	..	..	..	..	..
Rice (Bhunji)	20	..	..	..	..	..	..	..	..	..	..	..

This copy has been taken from the office of Lyallpur Tehsil.

ANNEXURE III.

Irrigation Statement for Lyallpur Division for the last seven kharif years.

Name of Crop.	Sugar- cane.	Munj.	Kapas.	Indigo.	Malzo.	Juar.	Miscel- laneous.	TOTAL.
	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.
1910	14,013	1,896	38,278	37	28,205	50,333	16,436	140,223
1911	0,117	1,123	54,070	..	22,045	58,401	18,420	155,785
1912	0,783	1,521	47,070	69	23,405	47,054	31,397	101,280
1913	12,002	357	30,802	51	18,357	34,888	10,536	126,073
1914	11,061	1,101	56,369	57	22,609	38,126	27,908	157,324
1915	12,250	1,330	34,269	20	28,048	43,531	26,250	146,737
1916	15,912	1,318	37,981	71	27,758	51,835	24,170	159,125
TOTAL IRRIGATION FOR SEVEN YEARS	82,218	8,739	309,433	314	170,517	310,218	164,117	1,054,556
AVERAGE IRRIGATION PER CROP	11,745	1,210	41,205	45	24,350	45,602	23,415	150,650
AVERAGE CULTIVATION PER 100 ACRES	2.3	0.2	8.5	..	4.7	8.8	4.5	29.0

ANNEXURE IV.

Irrigation Statement for Lyallpur Division for the last seven rabi years.

Name of Crop.	Toria.	Wheat.	Barley.	Derara.	Gram.	Senji.	Miscel- laneous.	TOTAL.
1910-11	64,144	243,016	3,385	868	22,431	27,062	8,516	309,380
1911-12	58,779	217,731	4,663	395	26,035	26,615	9,656	372,704
1912-13	66,900	219,257	2,608	516	20,001	22,094	8,788	311,453
1913-14	63,032	228,506	2,186	25	21,229	23,078	6,834	315,843
1914-15	53,027	238,060	4,161	787	29,321	27,281	8,730	361,085
1915-16	50,620	240,414	3,913	156	23,842	26,367	6,617	352,178
1916-17	68,304	239,767	2,673	603	18,866	22,252	6,006	340,951
TOTAL IRRIGATION FOR SEVEN YEARS	425,115	1,618,474	23,382	3,679	161,728	176,479	54,646	2,493,503
AVERAGE IRRIGATION PER CROP	60,731	235,406	3,340	525	23,104	25,211	7,807	356,214
AVERAGE CULTIVATION PER 100 ACRES	11.7	46.5	0.6	0.1	4.5	4.0	1.5	68.6

NOTE.—The cultivable area in the Lyallpur Division is 517,582 acres, but the area taken to work out the average is 518,000.

Punjab.]

Mr. AGA MOHAMMED MIRZA.

Sardar Sahib CHAUDHURI AMR SINGH called and examined.

(Translation.)

3518. (Mr. Ashton.) I have thirty years service. I was a Sub-overseer for eight years, a Zilladar for fifteen years and have been a Deputy Collector for the last seven years. At present *zamindars* are thinking of bringing a greater area under cotton and if present prices continue, they will give up some of the area under wheat for cotton. If the water rate for maize were reduced, the area under maize would increase, but maize would not compete with cotton. The cultivators prefer maize to wheat for food.

3519. The canal supply in April, May and June is governed by the *zamindari* demand. Under present conditions, the full supply in the canals cannot be run in April, May and June because the demand is not sufficient. Regulation would not be harder if the demand during these months were keener than it is at present. In April, May and the middle of June, the *zamindars* do not clear their water courses so frequently or keep them in such good order as they do in the *rabi*. If they kept them in the same order as they do in *rabi*, the outlets would give more water, but they do not take the trouble as there is not enough demand for water in *kharij*. If the demand in *kharij* was keener and cotton sowings were started from April 1st, the regulation of supply would be made easier.

3520. I have worked on the inundation canals in Shahpur district for ten years. In the inundation canal areas, the *zamindars* do sow a little cotton on well irrigation, afterwards giving supplies from the canals but usually they sow on canal water and if canal supply fails, the cotton matures on the well supply. I think cotton next year will increase by two *killas* per square.

Mr. AGA MOHAMMED MIRZA, Zilladar, Multan Canal Division, Multan.

EXAMINED AT LYALLPUR, JANUARY 12TH 1918.

Written statement.

I.—AGRICULTURAL EXPERIENCE.

(a) "*Deshi*" short-staple cotton.

3521. (1) Experience.—I have been stationed for five years in Ludhiana, three years in Ferozapore seven years in Lyallpur, and for five years in Multan district. I have been in actual touch with cotton cultivators.

3522. (2) Varieties.—I will mention here of the Multan district, where I have been last stationed. As everywhere else in the above districts, here in Multan on the Sidhmal Canal, all varieties of *deshi* cotton are grown mixed due to the ignorance of cultivators. *Indicum* white and yellow flower; *neglectum*, white and yellow flower and Multani *rattar* are all mixed up and the only distinction the cultivators are aware of, is between *rattar* and other *deshi*. The cultivators believe *rattar* by far better than either *indicum* or *neglectum*.

3523. (3) Size of holdings.—The average size of holding is one *killa*, which is equivalent to four squares, amounting to ninety to 120 aeres. The average area under cotton per *killa* is twelve to fourteen aeres.

3524. (4) Yields and profits.—The average yield per acre is five maunds and the profit per acre is about Rs. 30.

3525. (5) Rotations and manures.—There is no rotation in the strict sense of the meaning, but generally wheat is followed by cotton, and the more enterprising cultivators prepare fallow lands in which they use cattle dung as the manure and more especially old *ara* lands which once formed banks and beds of the ancient canals and which are extensive in the irrigated tracts of this district.

3526. (6) Comparative returns.—As all *deshi* cotton is grown in a mixed form hence it is not possible to compare the return of *deshi* short-staple with *deshi* long-staple. Generally *deshi* short-staple predominates in this district. Exotic cotton has just found its way in this district, but the *zamindars* have come to realise that this fetches Rs. 3 per maund more than the ordinary *deshi* does.

3527. (7) Conditions affecting increase in area.—The fluctuations in the area under cotton on the Sidhmal are largely due to the Ravi River swelling early or late in the season. I attach a statement for the last five years from which it will appear that there is a marked increase in the area under cotton more especially in the year 1914-15 when the supply in the river had remained constant throughout the year. In the year 1912-13, the supply in the river had been earlier than 1913-14, and in the year 1916-17 the supply had come down very late. There is no possibility of an increase under *deshi* and if American cotton were encouraged it is more likely that *deshi* varieties would be checked and American would take its place, which is already taking hold gradually, and cultivators believe it to be the best of all varieties.

3528. (8) Uses of seed and seed selection.—*Zamindars* generally sell the entire stock of cotton keeping very little for their house consumption. Only the sensible and enterprising *zamindars* keep the selected seed (hand ginned) for their next harvest, but ordinarily the common cultivator buys its seed from the local *bania* who in turn gets it from market where it is brought from factories. This is the reason why we now see the American seed mixed up in the *deshi* varieties on a good scale. Hand-ginned seed is preferred more than the market seed, and most sensible *zamindars* keep their seed hand-ginned selected from healthy plants.

3529. (9) General economic condition.—Cultivators over here have come to realise the advantages of American cotton over the *deshi* varieties. Of course, they already know that Multani *rattar* is better than *indicum* and *neglectum* both yellow flowers but they also know that American is far superior than either *deshi* variety. If *zamindars* are given concession in the water rates, say at half rates for three years, they will surely adopt the American variety and keep it unmixed. Last year, although the supply in Ravi was very late the *zamindars* had sown American in a few plots and this year again, although the cotton sowing time had elapsed, still *zamindars* had managed to grow cotton on the wells and even on canal water. This year, the area under American cotton has fairly increased from that of the last year, and the American has stood the test of late sowing and abnormal rainfall. It has thriven well under the same conditions of climate and soil and has stood superior in each and every respect to *deshi*. Although the sowing of American had been conducted on the orthodox line, still the outturn has proved a little better than *deshi* in comparison with equally good *deshi*.

Punjab.]

Mr. AGA MOHAMMED MIRZA.

[Continued.]

VI.—IRRIGATION.

3530. (50) Experience.—I have experience of canal assessment work, having been a *zilladar* on perennial canals.

3531. (51) Wheat *versus* cotton.—The cultivators prefer wheat to cotton for the following reasons :—

- (a) It is a staple food.
- (b) It is easy to cultivate, and suitable to all climates and soil and is very drought resisting.
- (c) It has an insurance of standard value and has very little fluctuation in prices.
- (d) It serves as a green fodder and gives any amount of dry fodder in the shape of *bhusa*.
- (e) It is a bumper crop and gives a respectable heavy outturn in general.
- (f) It does not require scientific methods of cultivation.
- (g) It does not require much manuring.
- (h) Generation after generation have proved its efficiency and usefulness due to unforeseen chances of drought and dearth.
- (i) It can be stored without much damage for a considerable time if there is no value for it in the market.

3532. (52) (a) Critical period in regard to water supply.—The critical period is April and October. If there were an increase in the irrigated area under cotton, it will cause either late sowing of wheat which is objectionable from the miller's point of view, because the grain does not become supple and is deteriorated ; or would reduce the quality and quantity of cotton then standing in need of water. October is more critical than April. In April, if water is much needed the only effect which it will cause on cotton would be a little late sowing of that crop.

3533. (52) (b) Watering of cotton.—Cotton is watered with an interval of fifteen to twenty days and three inches of watering is all what is required of it for one watering.

3534. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—The sowing of cotton under wells would be possible on Sidhnai canal, as has already been done in certain places last year when the supply was very late and this year as well. There are certain tracts in which a combination of well and canal irrigation would be possible in the case of American cotton.

3535. (56) (b) Extension of irrigation under wells in canal areas.—Generally, on Sidhnai each well is meant for fifty acres of land. Where there is more land on a well than fifty acres, *zamindars* are sinking new wells every year to the best of their means, available, and are extending irrigation of their own free will.

3536. (58) Cropping and causes affecting it.—The following table gives a rough estimate of the average area of each crop grown on a holding of 100 acres.

Kharif—						Rabi—					
					Acre.						Acre.
Cotton	.	.	.	.	14	Wheat	.	.	.	.	25
Rice	.	.	.	.	4	Fodder	.	.	.	.	4
Juar	.	.	.	.	4	Gram	.	.	.	.	8
Sesamum	.	.	.	.	4	Barley	.	.	.	.	1
Indigo	.	.	.	.	1						
Toria	.	.	.	.	2						
					29						38

That is for an average area per holding of 100 acres.

3537. (64) Suitability of water rates.—I don't think that water rates charged have any effect whatever on the cultivators preference of a particular crop, hence no changes are called for in the schedule of water rates.

ANNEXURE.

Area under wheat and cotton for the last five years' fluctuating according to the supply of water in the Sidhnai Canal in Multan District.

Name of crop.	1912-13.		1913-14.		1914-15.		1915-16.		1916-17.		REMARKS.
	Wheat.	Cotton.	Wheat.	Cotton.	Wheat.	Cotton.	Wheat.	Cotton.	Wheat.	Cotton.	
Kharif	..	29,124	..	25,314	..	45,567	..	20,004	..	2,810	
Rabi	63,780	..	71,394	..	99,933	..	63,934	..	87,541	..	

Mr. AGA MUHAMMAD MIRZA called and examined.

3538. (Mr. Ashton.) I have twenty years' service on the Sirhind, Lower Chenab and Multan Canals. In the Multan District, in certain years when the supply in the rivers is very late and the time of sowing is passing, the *zamindars* sow cotton on well irrigation. If the *zamindars* were made more fully aware of the advantages of American cotton, it is very likely that they would increase the area under it. The only thing I can suggest for promoting the area under American cotton is the use of wells. The canals in the Multan District do not open till the end of May, but the *zamindar* could start irrigating cotton from wells. If some concessions were given in the way of the remission of charges on fodder for cattle or say only half water rates were charged for cotton for three or four harvests, it might promote the growth of American cotton. The present water rate on cotton is not a very heavy item against an increase. I suggest reducing it simply as a stimulus to *zamindars*.

Punjab.]

Mr. F. T. BATES.

3539. I have been seven years on the Lower Chenab Canal as Zilladar. The supplies in the canal from April to July are regulated by the demand of the *zamindars*. The *zilladar* indents for supplies on the Sub-Divisional Officer, and the Sub-Divisional Officer indents on the Executive Engineer. I have been in Burala, Upper Gogera and Khauki Divisions. In these divisions, the Sub-Divisional Officer does the regulation.

3540. The regulation and distribution of the water supply would be easier if the demand for water during April, May and June was keener than it is now, because at that period there is any amount of water in the river and there is no necessity for running the canals and branches by rotation. The *zamindars* do not keep their watercourses as clean during *kharij* as they do in the *rabi* because they know that there will be no shortage of water in the hot season; whereas, in the *rabi* season every drop of water is required. They would be able, no doubt, to get more water by clearing their watercourses more frequently in the *kharij* than they do at present.

3541. There is no possibility of an increase of *deshi* cotton on the Sidhnai Canal. Maize and other crops have already been given up on a small scale for cotton. If these waters were available in the canal say in March or the beginning of April, I think there would be an increase under cotton. Even if canal water were available then, I do not think that the *zamindars* would give up wheat for cotton, but they would grow American instead of *deshi*. There would be an increase in the total area under cotton but it would not be very much. Land, which is not already under cultivation, would be brought under cultivation.

3542. There is only one tube well in the area under the Sidhnai Canal at Mahmudiyal. It is in my section. It was put down by Rai Bahadur Ram Saran Das of Lahore. It was worked last year for a couple of months till such time as water became available in the canals. After that it stopped, and has not been worked since, as there was any amount of water this year in the river.

3543. (Mr. Roberts.) I was in the College class for Extra Assistant Commissioners two years ago. In 1916-17, the supply in the river Ravi was very low. There was a big drop in 1915-16 and in 1916-17. The supply in the river Sidhnai was very late; it is supposed to be a semi-perennial canal. I think that, other things being equal, the carrying out of the Haveli project would make the cultivation of American cotton very secure. This year there will be a large area of American cotton. 1,500 acres are doing well under present conditions. If the water could be guaranteed at the beginning of April, *deshi* cotton would be replaced by American. As regards demands for water in September, there is not very much trouble. Any how the *zamindars* make both ends meet. They give water to cotton very economically and go on making preparations for the coming *rabi*. There is not very great difficulty in October either. The supply in the Sidhnai begins to fail about the end of September as a rule. This year's supply is still flowing with little interruption. American cotton has got a very good chance this year. Supplies came in about the end of May. Though the American cotton has been sown late this year, it is doing very well.

Mr. F. T. BATES, Superintending Engineer, Lower Chenab Canal Circle, Punjab.

EXAMINED AT LYALLPUR, JANUARY 14TH 1918.

Written statement.

VI.—IRRIGATION.

3544. (50) Experience.—My experience of irrigation is limited to canals in the Punjab and covers about seventeen years including canal irrigation assessment work.

3545. (51) Wheat *versus* cotton.—On the Lower Chenab Canal, there is a decided preference for wheat over cotton. Take, for instance, the best cotton growing Branch of the Canal, the Bhawana Branch and compare the cotton area with that of wheat for the past three years. Cotton, 14,101 acres, wheat 43,800 acres, on an average annual irrigated area of 1,00,000 acres. The percentages therefore are :—

Cotton 14.1 per cent of annual irrigation and

Wheat 43.8

" " "

on the best cotton growing branch of this canal.

(2) Again, taking this canal as a whole, the annual irrigation is, on the average, 23,00,000 acres of which wheat is in round figures 10,00,000 acres and cotton 1,86,000 acres. The percentages of annual irrigation are :—

Cotton 8 per cent and

Wheat 43.5 per cent.

The reason for this preference is entirely economic. The wheat crop all told pays better.

3546. (52) (a) Critical period in regard to water supply.—As the Lower Chenab Canal is now linked to the four other canals drawing on the combined supply of the Chenab and Jhelum rivers, I consider that the months of March and September are the critical periods, particularly the former. I don't think an increase of the cotton area up to fourteen per cent of annual irrigation need necessarily be affected to more than a very limited extent. The Bhawana Branch cotton area, which is large, is not as a rule in any difficulty from the critical conditions prevailing in March and September and I presume that, if the Bhawana Branch can do as much as fourteen per cent of its annual irrigation in cotton, this percentage, at least, could equally well be done over the whole canal, assuming other conditions than water supply to be favourable.

3547. (52) (b) Watering of cotton.—Cotton on this canal is usually watered from April onwards to October. This volume of water per acre is not ascertainable. No water is, as a rule, taken for cotton in March, although the variety of cotton cultivated is chiefly American long staple.

3548. (52) (c) Statistics.—*Vide* Annexures III, IV and V.

3549. (53) (a) Possibilities of expansion of area under cotton by enlargement of canals.—I take it that the cotton area on the linked and *kharij* canals which draw on the combined supply of the Chenab and Jhelum rivers will be limited to the supply available in those rivers in the months of April and May during which cotton sowings are chiefly made. If this is so, then, all that it is necessary to examine is the present maximum carrying capacities of the linked and *kharij* canals compared with the normal combined supply of the Chenab and Jhelum rivers in April and May.

Punjab.]

Mr. F. T. BATES.

[Continued.]

(2) If the whole river supply, Chenab and Jhelum, for April and May can, through the medium of existing canals, perennial or otherwise, on these rivers be conveyed to the lands on them, it does not seem necessary to further increase the capacities of the canals for the accommodation of supplies available in June, July and August.

(3) The combined rivers, Chenab and Jhelum, may be considered to give in April and May a normal volume of from 50,000 to 60,000 cusecs, of which the linked canals can dispose of 32,000 cusecs, leaving some 20,000 cusecs for canal systems lower down these rivers. If these 20,000 cusecs are utilized in *kharif* canals lower down as effectively as they would be in the perennial canals, it seems unnecessary to concentrate the river volume in the perennial canals at great expense particularly as it might starve areas more suited to cotton growing elsewhere than on the perennial canals.

(4) There is, too, this disadvantage in the concentration of river volume for cotton sowings on any set canals, viz., that growers may for economic reasons abandon cotton and take up instead some other crop. The more essential need for permanently establishing long staple cotton cultivation appears to call for improving the water supply in those particular areas in the Punjab where cotton has already established itself.

(5) I think that, at any rate, until the demand for water in April and May on these linked canals exceeds the maximum carrying capacity, their enlargement should not be undertaken.

3550. (53) (b) Effect of enlargement of canals on area under wheat.—It is, I believe, unlikely that the wheat area will be largely reduced at the expense of cotton. The limit to the cotton area is the available river supply in April and May. Take the Lower Chenab Canal, for instance. Its authorized supply is 10,730 cusecs at head and it has actually carried 11,000. Supposing the canal enlarged to carry 15,000 cusecs, the available river supply in the Chenab river in April, the total *kharif* area that could be matured with 15,000 cusecs at canal head would be $15,000 \times 60$, i.e., 9,00,000, acres as compared with 7,00,000 acres now obtaining. The excess, 2,00,000 acres *kharif*, would give at the most 50 per cent., i.e., 1,00,000 acres of cotton. The present wheat area is 10,00,000 so that if the whole of the extension of cotton due to increased supply were made at the expense of wheat it would reduce the wheat area by not more than one-tenth.

3551. (54) (a) Improvement in duty of water by remodelling of outlets.—On the Lower Chenab Canal the main principles aimed at in the recent remodelings are (1) to give the same volume of water per given unit of area all over the canal and (2) to give that volume with as little interruption as possible.

3552. (54) (b) Utilization of modules.—The modules used are chiefly Mr. Kennedy's and are known as the Kennedy Gauge Outlets from their being on each outlet a gauge intended to indicate the discharge passing through at any time. They have their limitations but, taking all things into consideration, they have been found in actual use, where correctly installed, to fulfil their object. They meet the requirements of both principles quoted above, for, by their means, a definite volume of supply under normal conditions of flow in distributary channels can be assured and thus a definite volume per unit of area is given. The interruptions in supply are reduced to a minimum from the fact that there is no need on channels so fitted to close head outlets to get water down to the tail. All outlets run uniformly throughout. The moduling of channels is a necessity where the extent of land available is greater than the supply of water. A saving of water of at least ten per cent can be got on that consumed in unmoduled channels as at present outletted and if it is a question of either enlarging a canal to carry a tenth more water or to module the channels and thus save this tenth, I think the latter a better solution in every way.

3553. (55) Fluctuations in river supplies and their effects.—The rise and fall of the Chenab river is gradual. The fact that the *kharif* area on this canal compared with the *rabi* is as seven to sixteen and that of the *rabi* the wheat crop is $\frac{3}{8}$ this makes it possible that the rise and fall of the river supply has assisted to bring about these conditions. At any rate, the wheat crop is the premier crop on this canal and its cultivation is suited to the river condition generally prevailing. There is however nothing in the rise and fall of the river against the extension of cotton.

(2) For Diagram of rise and fall of river Chenab vide Annexure VII.*

3554. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—The tract on the Lower Chenab Canal answering to the description in this is the Hafizabad Tahsil of the Gujranwala District. In this tract, the percentage of cotton to the whole *kharif* area is small and I understand that the soil is unsuited to cotton cultivation.

3555. (56) (c) Tube wells.—I have had very little experience with tube wells but, if I were called upon to decide how best to establish in India a supply of long staple cotton commensurate with the importance and permanency of the Home industries to be safeguarded, I would prefer to concentrate all effort in those areas where the soil and climate are most suitable for the crop and to utilize well-irrigation augmented by deep tube supply to any other. I would prefer to work on concentrated areas managed by individuals trained for the purpose of cotton growing and would urge specialization throughout all the stages of the cultivation of the crop. In this way alone, do I think, is security against failure to be attained. Effort spread out over large areas, where holdings are small and where any attempt at organized training or specialization in procedure is impossible, will be wasted and at the best will not produce stability. There are many advantages in concentration where skilled action has to be inculcated and if areas are judiciously selected as to soil, climate, and water supply, the result will be far more satisfactory, I believe, than if reliance is placed upon the choice of uninformed cultivators spread all over the province working under conditions, some good, some bad and easily turned from one choice of crop cultivation to another on the first set back.

3556. (56) (d and e) Construction of weirs *versus* construction of wells.—I do not think that any canal system on which the land is in excess of supply can ever compete with well irrigation in correct rotation of supply. I do not consider it worth while attempting any alteration in canals coming under the above description.

3557. (58) Cropping and causes affecting it.—On the Lower Chenab Canal the following figures give a good average per square of 25 killas:—

Rabi.		Kharif.	
Wheat	10	Cotton	2
Toria	1	Maize	1
Fodder	1	Fodder	3
Gram	1	Sugarcane	1
Miscellaneous	2		
16 killas.		7 killas.	

Punjab.]

Mr. F. T. BATES.

[Continued.]

In the above it may be assumed that the *toria*, fodder and miscellaneous crop areas respectively $\frac{2}{3}$ ths, $\frac{1}{8}$ th and $\frac{2}{8}$ ths of the total *rabi* will not change. If cotton is extended, it will be at the expense of gram and wheat areas only.

3558. (59) *Practicability of lining canals.*—I consider the lining of canals in selected reaches a practicable measure and essential to their continued utility.

3559. (60) *Cost of lining canals.*—The cost will vary largely on the canal to be lined and the nature of lining adopted. As it will never be necessary to line more than certain lengths of canals, the cost per acreage is not ascertainable, until the lengths to be lined are known and the kind of lining decided on.

3560. (61) *Enlargement and lining of canals.*—The possibility of carrying out lining in conjunction with enlargement will depend on the circumstances of each case. Diversion cuts might be necessary if closures cannot be given.

3561. (62) *Effect of lining canals on seepage problems.*—The seepage problem is one which will determine the life of a canal and expenditure on lining will be found in any case not inordinate taking into consideration the interests involved.

3562. (63) *Effect of lining canals in supplies.*—I don't think the improvement of supply either in the winter or the summer so great a matter as that of saving the country from certain ruin by waterlogging. There will be a certain quantity of water saved but this alone is insignificant and may be neglected. It is the safety of the country irrigated that has to be provided for.

3563. (64) The water rates charged have no effect on the cultivator's preference in the case of any crop.

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Mr. F. T. BATES.

[Continued.]

ANNEXURE I.

Lower Chenab Canal.

Statement showing number of acres per cusec of discharge (three years average) at the Head of each Branch for Kharif 1914, 1915 and 1916, and rabi 1914-15, 1915-16, and 1916-17, and percentage of cotton and other principal crops to the whole kharif area matured on each branch during Kharif 1914, 1915 and 1916.

Name of Branch.	NUMBER OF ACRES PER CUSEC OF DISCHARGE (3 YEARS AVERAGE) AT THE HEAD OF THE EACH BRANCH.								Average kharif area matured 1914, 1915 and 1916 (3) crops.	Cotton area matured out of that shown in column 10.	Percentage column 11x100 column 10 acres.	PRINCIPAL CROPS OUT OF THAT SHOWN IN COLUMN 10.												
	Kharif.				Rabi.							Sugar-cane.	Rice.	Maize.	Juar and chari.	Miscellaneous.								
	1914.	1915.	1916.	Average of columns 2 to 4.	1914-15.	1915-16.	Average of columns 6 to 8.	9									10	11	12	13	14	15	16	17
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17								
Main Line Distributaries	82	80	104	83	184	257	221	220	28,529	1,400	5	843	20,488	307	2,770	2,652								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Kot Nikka Branch	70	71	102	81	189	201	251	214	16,185	1,639	10	881	5,478	530	3,417	4,240								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mian Ali Branch	91	89	88	89	215	256	276	240	16,990	14,251	30	4,241	1,859	7,345	12,307	6,096								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rakhi Branch	63	62	85	70	252	297	343	297	14,561	2,407	16	1,733	1,797	1,381	1,622	5,621								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rakhi Branch	84	86	90	87	229	274	263	255	72,562	17,123	24	8,463	322	11,724	21,951	12,770								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Jhang Branch Upper	67	60	71	66	178	209	236	208	80,566	23,474	32	4,576	941	13,049	22,394	13,232								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Jhang Branch Lower	80	91	80	83	233	234	158	208	82,466	23,198	28	8,500	412	10,488	26,729	13,138								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Bhavana Branch	97	139	95	110	208	243	200	237	34,892	14,101	40	70	1	13	32	76								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gugera Branch Upper	69	65	66	67	172	255	224	217	82,102	27,939	34	7,226	4,488	10,347	19,756	12,346								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Gugera Branch Lower	72	70	77	73	188	246	262	232	127,715	35,380	28	14,977	33	25,891	35,478	15,756								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Buraha Branch	92	84	91	89	202	242	288	244	102,569	32,743	32	3,311	771	16,531	28,009	21,504								
Percentage of column 10	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Punjab.]

Mr. F. T. BATES.

[Continued.]

ANNEXURE II.

Statement showing average daily supply of river at Khanki, i.e., (canal supply and escape over weir), for the past seventeen years, for the months noted below :—

Name of the month.	Periods.	1900.	1901.	1902.	1903.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	1911.	1912.	1913.	1914.	1915.	1 16.	REMARKS.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
April . .	1st half.	13,369	11,138	8,917	15,012	11,663	16,876	24,405	28,778	23,374	18,453	16,279	23,172	22,350	10,776	16,372	14,516	7,246	Average. 10,088
April . .	2nd "	10,935	10,395	16,539	23,363	14,632	14,632	23,417	48,115	18,748	14,289	13,803	21,155	22,554	11,646	10,725	14,010	9,161	17,479
May . .	1st "	14,697	16,073	23,975	23,583	19,744	35,296	22,639	26,268	22,935	23,615	23,249	26,063	10,614	20,037	20,942	20,638	11,749	21,816
May . .	2nd "	20,707	16,755	29,799	24,632	19,794	43,143	33,817	34,049	25,729	24,369	30,190	34,677	20,443	21,930	19,413	23,850	14,502	25,754
October . .	1st "	12,561	22,624	16,370	21,211	13,389	17,072	19,464	15,330	11,889	20,425	13,968	17,370	10,416	9,999	10,203	13,094	26,078	15,968
October . .	2nd "	11,865	12,437	9,815	15,391	10,039	10,794	12,769	10,853	12,019	18,646	12,103	11,612	8,653	8,436	10,639	9,004	8,687	11,398

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Mr. F. T. BATES.

[Continued.]

ANNEXURE III.

Statement showing the average monthly flow of the branch canals of the Lower Chenab Canal and the average monthly area of each kharif crop irrigated.

Branch Canal.	Average Discharge of 3 years ending 1917.	AVERAGE MONTHLY AREA IRRIGATED OF EACH CROP FOR 3 YEARS, 1915, 1916, 1917.							TOTAL AREA IRRIGATED.
		Sugar-cane.	Rice.	Cotton	Indigo.	Malze.	Juar and Char.	Miscellaneous	
1	2	3	4	5	6	7	8	9	10
<i>April.</i>									
Main Line Distys	135	370	..	125	..	..	100	1,065	2,560
Kot Nikka	137	210	..	200	..	..	200	1,705	2,315
Mian Ali	452	3,843	..	6,401	..	..	1,050	4,522	15,011
Rakh	021 { H. L.	1,120 8,622	..	1,575 8,812	.. 44	.. 48	800 4,083	30 5,458	3,534 27,007
Jhang Branch, Upper	1,083	4,486	..	12,027	1	127	3,734	5,015	25,303
Jhang Branch, Lower	074	7,793	..	11,013	1	..	2,432	4,048	25,787
Bhawana Branch	317	238	..	6,971	..	10	425	1,334	8,081
Gugera Branch, Upper	1,243	5,610	..	11,810	..	120	2,764	6,296	26,610
Gugera Branch, Lower	1,035	15,648	..	12,458	21	154	3,037	10,296	42,514
Burala Branch	081	3,357	..	10,902	4	741	1,015	10,085	27,000
<i>May.</i>									
Main Line Distys	257	100	..	100	..	2	400	5,750	0,352
Kot Nikka	142	229	..	400	..	2	000	1,004	2,316
Mian Ali	518	800	0	7,600	..	27	2,663	2,624	13,020
Rakh	1,004 { H. L.	580 660	.. 2	1,400 6,730	.. 28	1 30	1,100 5,200	1,153 3,282	4,234 16,007
Jhang Branch, Upper	1,100	434	1	10,605	2	208	5,167	3,455	20,052
Jhang Branch, Lower	1,163	1,104	7	7,712	..	22	8,020	4,244	16,100
Bhawana Branch	262	30	..	4,542	..	14	820	1,200	605
Gugera Branch, Upper	1,221	1,087	11	14,377	16	200	4,402	4,013	25,000
Gugera Branch, Lower	1,702	868	1	10,412	3	141	7,803	7,230	35,467
Burala Branch	1,052	770	..	17,120	14	1,925	6,562	8,613	35,010
<i>June.</i>									
Main Line Distys	374	16	15	20	..	..	200	8,664	8,015
Kot Nikka	174	30	7	35	..	3	300	2,107	2,542
Mian Ali	451	58	30	403	..	44	1,411	1,237	3,272
Rakh	1,088 { H. L.	144 150	88 20	545 1,180	4 2	2 168	1,200 4,060	218 3,015	2,201 9,213
Jhang Branch, Upper	1,237	40	46	1,151	..	244	4,568	4,503	10,612
Jhang Branch, Lower	1,130	8	50	2,320	..	12	4,852	5,272	12,524
Bhawana Branch	410	6	48	1,031	..	50	1,028	1,001	5,578
Gugera Branch, Upper	1,486	210	37	2,284	..	113	3,218	3,588	9,450
Gugera Branch, Lower	1,692	45	1	2,504	4	113	7,328	8,426	18,511
Burala Branch	1,119	75	26	2,085	..	573	2,865	6,796	12,420
<i>July.</i>									
Main Line Distys	335	..	2,400	..	..	..	100	3,621	6,121
Kot Nikka	158	40	300	30	..	..	700	1,544	2,614
Mian Ali	480	..	513	28	..	141	1,806	1,321	3,809
Rakh	1,054 { H. L.	.. ..	300 136	10 1	.. 4	40 764	500 4,530	681 4,005	1,531 10,359
Jhang Branch, Upper	1,335	..	340	4	..	1,227	4,337	3,106	8,023
Jhang Branch, Lower	1,108	31	96	20	..	014	5,417	5,602	12,170
Bhawana Branch	435	20	43	1	..	123	3,085	1,450	4,731
Gugera Branch, Upper	1,218	9	485	146	3	454	2,415	2,504	6,010
Gugera Branch, Lower	1,052	..	3	89	1	1,355	8,015	11,565	21,631
Burala Branch	1,186	4	44	32	..	1,575	5,882	8,370	16,207

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Mr. F. T. BATES.

[Continued.]

ANNEXURE III—continued.

Statement showing the average monthly flow of the branch canals of the Lower Chenab Canal and the average monthly area of each kharif crop irrigated—contd.

Branch Canal.	Average Discharge of 3 years ending 1917.	AVERAGE MONTHLY AREA IRRIGATED OF EACH CROP FOR 3 YEARS, 1916, 1917.							TOTAL AREA IRRIGATED.
		Sugar-cane.	Rice.	Cotton.	Judgo.	Malze.	Jawar and Chari.	Miscellaneous.	
1	2	3	4	5	6	7	8	9	10
<i>August.</i>									
Main Line Distys. . . .	359	..	3,200	..	..	50	1,090	1,290	5,456
Kot Nikka	140	..	1,999	..	..	150	1,599	1,182	3,832
Mian Ali	440	..	684	1	..	3,977	2,664	1,436	8,762
Rakh	963	H. L.	890	..	..	1,399	590	269	2,869
Jhang Branch, Upper . .	1,131	..	304	1	..	8,222	7,193	5,376	21,102
Jhang Branch, Lower . .	1,235	37	26	255	..	6,903	8,019	4,149	29,337
Bhawana Branch	499	..	35	..	..	847	5,425	2,984	8,391
Gugera Branch, Upper . .	660	..	2,432	1	..	3,986	4,676	2,160	13,281
Gugera Branch, Lower . .	1,696	..	..	..	25	14,749	6,069	5,740	27,192
Burala Branch	608	—11	447	78	..	8,300	9,226	4,113	22,153
<i>September.</i>									
Main Line Distys. . . .	316	..	80	..	..	29	50	725	875
Kot Nikka	157	..	..	..	..	39	200	466	606
Mian Ali	467	..	8	..	..	1,039	689	578	2,305
Rakh	1,005	H. L. . . . .	..	11	..	200	450	457	1,118
Jhang Branch, Upper . .	1,107	..	59	..	..	1,711	2,337	2,131	6,265
Jhang Branch, Lower . .	1,206	..	27	..	1	1,380	3,030	3,084	7,524
Bhawana Branch	381	..	3	1	..	184	1,047	1,300	3,111
Gugera Branch, Upper . .	1,169	..	684	1	..	1,682	1,706	883	4,916
Gugera Branch, Lower . .	1,578	..	..	..	..	1,611	652	2,505	5,998
Burala Branch	1,068	—3	165	—69	1	2,619	2,484	—324	4,873

ANNEXURE IV.

Statement showing the average monthly flow of the branch channels of the Lower Chenab Canal and the average monthly area of each rabi crop irrigated.

Branch Canal.	Average Discharge of 3 years, ending 1917.	AVERAGE MONTHLY AREA IRRIGATED OF EACH CROP FOR 3 YEARS 1916, 1917.							TOTAL AREA IRRIGATED.
		Wheat.	Barley.	Mixed grain.	Torla and sarson.	Gram.	Senji.	Miscellaneous.	
1	2	3	4	5	6	7	8	9	10
<i>October.</i>									
Main Line Distys. . . .	295	699	199	..	..	59	125	5,496	6,271
Kot Nikka	164	700	..	..	990	159	125	3,291	5,165
Mian Ali	569	18,388	180	74	14,372	1,397	1,274	7,823	33,427
Rakh	1,919	H. L.	6,840	190	109	6,109	909	..	14,448
Jhang Branch, Upper . .	1,271	22,494	443	7,341	721	29,355	3,284	16,346	71,981
Jhang Branch, Lower . .	1,138	10,385	372	1,076	22,632	7,065	1,987	17,069	69,197
Bhawana Branch	395	3,924	112	6	11,986	385	63	3,067	17,743
Gugera Branch, Upper . .	1,249	7,953	165	241	25,853	1,044	1,246	11,559	48,961
Gugera Branch, Lower . .	1,824	22,336	425	714	48,931	15,189	6,169	37,736	1,31,482
Burala Branch	1,252	14,953	646	653	39,119	4,888	3,695	28,169	91,214

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- Mr. F. T. BATES.

[Continued.]

ANNEXURE IV—continued.

Statement showing the average monthly flow of the branch channels of the Lower Chenab Canal and the average monthly area of each rabi crop irrigated—contd.

Branch canal.	Average discharge of 3 years, ending 1917.	AVERAGE MONTHLY AREA IRRIGATED OF EACH CROP FOR 3 YEARS 1915, 1916, 1917.							TOTAL AREA IRRIGATED.
		Wheat.	Barley.	Mixed grain.	Turnip and sarson.	Gram.	Sauji.	Miscellaneous.	
1	2	3	4	5	6	7	8	9	10
<i>November.</i>									
Main Line Distys.	74	366	56	..	..	160	06	3,563	4,673
Kot Nikka	120	2,006	50	..	600	200	00	2,105	5,045
Mian Ali	521	25,951	342	43	370	1,618	3,360	5,160	36,259
Rakh	630 { H.	9,700	206	..	200	206	250	3,274	13,824
	{ L.	47,061	959	4,855	2,028	202	6,406	0,157	68,268
Jhang Branch, Upper	1,135	56,642	1,005	4,604	3,414	602	7,022	5,871	83,669
Jhang Branch, Lower	1,162	53,319	1,427	2,186	1,009	5,004	4,675	0,622	74,237
Bhawana Branch	385	16,414	477	33	633	281	766	1,211	16,817
Gugera Branch, Upper	923	44,838	1,613	726	2,091	1,627	4,514	7,408	62,310
Gugera Branch, Lower	1,083	81,612	1,158	1,751	411	7,352	6,366	14,818	1,18,628
Burala Branch	1,137	55,405	711	932	1,728	2,345	5,331	754	67,207
<i>December.</i>									
Main Line Distys.	42	4,000	56	..	146	166	260	38	4,528
Kot Nikka	133	8,900	100	..	260	260	406	2,782	11,682
Mian Ali	267	21,651	107	215	135	666	3,682	2,843	36,203
Rakh	573 { H.	10,006	150	36	..	406	406	246	11,232
	{ L.	15,066	427	839	503	11	3,067	1,468	21,654
Jhang Branch, Upper	661	15,484	375	520	295	45	2,657	1,120	20,865
Jhang Branch, Lower	737	44,661	602	2,070	686	2,310	4,617	4,718	56,513
Bhawana Branch	239	19,841	566	21	127	280	1,712	1,848	23,961
Gugera Branch, Upper	630	52,412	792	514	1,673	1,785	6,241	6,646	66,763
Gugera Branch, Lower	1,476	58,833	564	714	46	3,238	7,566	5,498	76,540
Burala Branch	1,036	48,320	602	1,122	2,625	2,266	5,878	—715	60,102
<i>January.</i>									
Main Line Distys.	55	500	..	..	..	..	400	2,430	3,339
Kot Nikka	130	2,566	..	..	..	106	466	1,138	4,338
Mian Ali	307	1,223	51	..	..	62	338	437	2,112
Rakh	047 { H.	2,000	..	..	1	..	..	371	2,371
	{ L.	3,037	53	202	25	..	1,248	324	4,689
Jhang Branch, Upper	864	3,157	71	72	20	..	1,310	787	5,417
Jhang Branch, Lower	574	5,503	81	150	1	284	1,000	1,535	8,624
Bhawana Branch	250	4,418	75	24	..	68	738	582	5,935
Gugera Branch, Upper	680	4,604	66	256	22	138	1,465	1,413	7,421
Gugera Branch, Lower	1,261	4,415	26	17	..	648	1,533	1,436	8,659
Burala Branch	804	9,601	146	165	1,124	546	2,066	—716	12,026
<i>February.</i>									
Main Line Distys.	58	266	..	..	..	..	..	234	434
Kot Nikka	116	366	..	..	..	..	56	437	787
Mian Ali	442	462	..	..	..	1	319	613	1,335
Rakh	776 { H.	560	..	..	..	..	..	233	733
	{ L.	311	14	200	2	..	586	536	1,622
Jhang Branch, Upper	620	166	12	88	..	..	488	175	662
Jhang Branch, Lower	620	2,241	7	52	..	200	901	666	4,226
Bhawana Branch	316	111	..	..	..	27	—147	334	610
Gugera Branch, Upper	836	660	0	102	1	20	667	1,355	2,814
Gugera Branch, Lower	1,276	164	2	1	..	388	483	640	1,708
Burala Branch	857	6,128	126	18	52	705	2,255	469	5,553

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MR. F. T. BATES.

[Continued]

ANNEXURE. IV—continued.

Statement showing the average monthly flow of the branch channels of the Lower Chenab Canal and the average monthly area of each rabi crop irrigated—contd.

Branch canal.	Average discharge of 3 years, ending 1917.	AVERAGE MONTHLY AREA IRRIGATED OF EACH CROP FOR 3 YEARS 1915, 1916, 1917.							TOTAL AREA IRRIGATED.
		Wheat.	Barley.	Mixed grain.	Toria and sarson.	Gram.	Sonji.	Miscellaneous.	
1	2	3	4	5	6	7	8	9	10
<i>March.</i>									
Main Line Distys.	58	161	..	..	..	..	..	7	163
Kot Nikka	97	39	..	..	..	..	..	..	39
Main All	404	75	1	..	..	1	15	427	519
Rakh	867	H. .. L. 73	.. 3	.. 275	..	..	.. 542	23 386	25 1,270
Jhang Branch, Upper	811	167	132	35	18	..	829	298	479
Jhang Branch, Lower	665	305	22	17	9	111	166	218	851
Bhawana Branch	447	..	..	..	..	10	28	8	46
Gugera Branch, Upper	1,102	193	..	17	1	..	75	178	461
Gugera Branch, Lower	1,263	361	..	3	19	399	270	651	1,705
Burala Branch	912	721	17	—16	..	864	1,084	197	2,896

ANNEXURE V.

Maximum carrying capacity.

	Cusecs
Main Line, Lower Chenab Canal	11,400
Main Line Distributaries	560
Kot Nikka Branch	300
Rakh Branch	1,200
Mian Ali Branch	580
Gugera Branch, Upper	5,000
Included in } Gugera Branch, Lower	1,890
Gugera Branch, Upper	
Upper } Burala Branch	1,450
Jhang Branch, Upper	3,000
Included in } Jhang Branch, Lower	1,700
Jhang Branch, Upper	
Upper } Bhawana Branch	430

ANNEXURE VI.

Lower Chenab Canal.

Statement showing total culturable area commanded and total present permissible.

Name of Channel.	Total culturable area commanded.	Total present permissible.
(1) Main Line Distributaries including Kharif Distys.	1,03,097	45,354
(2) Kot Nikka Branch	82,932	41,482
(3) Mian Ali Branch	1,62,579	1,16,121
(4) Rakh Branch	2,92,256	2,13,953
(5) Jhang Branch Upper	6,97,684	4,39,241
(6) Jhang Branch Lower	3,49,196	2,26,402
(7) Bhawana Branch	1,29,860	80,790
(8) Gugera Branch Upper	10,557	7,918
(9) Gugera Branch Lower	4,19,280	3,13,920
(10) Burala Branch	3,35,327	2,41,605
TOTAL	25,82,798	17,26,786

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Mr. F. T. BATES.

[Continued.]

Mr. F. T. BATES called and examined.

3564. (Mr. Ashton.) I have stated in my written evidence that until the demand for water in April and May on the linked canals exceeds the maximum carrying capacity, their enlargement should not be undertaken. I have not found any necessity for enlarging the Lower Chenab Canal. The Canal has not been run to its full capacity. The full capacity is about 11,400 cusecs. Under present conditions, we never reach that full capacity or anything like it, even in October. You will see from Annexure II to my written evidence that the average discharge in the river during the first half of April is 16,500 and during the second half is 17,500, so that we could run a very much larger discharge in April than we are actually doing at present, if there were any demand for it. The supply run in the canal in April and May is always based upon the demand of the cultivators, and not on the opinions of the officers at the head-works of the canal or of the head of the division. If the cultivators wanted to double the cotton area, it would depend on the water available. We could give up to the full capacity of the canal, i.e., up to 11,400 cusecs. The present cotton area is about ten per cent of the total irrigation. The cotton area this year is 238,786 acres. The maximum supplies of the year are run in September and October. In present conditions the demand is keenest in September and October. The canal can safely carry 11,400 cusecs: that is the discharge for which it has been tested. It was designed for 10,700 cusecs. I should think that it would carry another fifteen per cent of 10,700 cusecs, its designed supply, without enlarging or without any very special engineering works. All that would be required would be a slight strengthening here and there and the cutting of berms. No alteration in masonry work would be required. As far as this canal is concerned, the position is that you have got the water for a very much larger supply from April onwards to the end of August, if there was a demand for it. With a slight expenditure on strengthening weak places and cutting berms, you could run the canal with fifteen per cent increase on its designed supply, 10,700, cusecs, that is you could run it up to 12,300 cusecs. That would be practically above the average river supply for the month of October.

3565. I am strongly in favour of lining canals more from the point of view of stopping waterlogging than of saving water. As to the cost of lining, we have previous experience of lining within short rotations of the canal. A point I wish to emphasize is that since all our lining operations were done during short periods of canal closure, the cost of lining, as we know it, is that incurred under these conditions not that which would apply under more favourable conditions. Any lining to be done could only be done in short rotations. On the Lower Chenab Canal, it would be possible to line the Main Line if the canal were closed at head for the last fifteen days in each of the months of November, December, January and February every year for about ten successive years. I would start by making all channels run half time in *rabi* instead of two-thirds time as at present, and increase their capacity if this were needed. I don't think the cost of this would be great as it implies giving nearly fifty* per cent increase over present average *rabi* supply, and not fifty per cent over present carrying capacity. If the channels were made half time as above, the rotational closures of fifteen days in November, December, January, and February would cause no inconvenience to crops and would afford sufficient time for lining operations. My present opinion after my latest inspection is that forty miles of the main line of my canal will have to be lined eventually. I do not say that it will have to be done immediately but I say that it will have to be done eventually.

3566. I do not know whether a great increase in the demand on the Upper Canals would affect the Haveli project. If there were 7,000 cusecs less available for the Haveli project, it would just be feasible on those figures. If this canal and the Lower Jhelum took out between them an extra 4,000 or 5,000 cusecs in October, it would have a very serious effect on the Haveli project. There would not be enough water for the Haveli project if those figures are to be relied on.

3567. I am strongly in favour of modules and I consider that there would be a considerable increase of irrigation if the whole canal were moduled. The water that was saved could be utilized on the canal.

3568. There is an area available for extension in this Colony. The question of taking it up has not yet been raised. It is in the Kowalia Tehsil of the Montgomery District on an extension of the Burela branch in the *khadir* tract of the Montgomery district. I do not know whether any cotton is grown there at present.

3569. As to the substitution of irrigation from tube wells for irrigation by canals, I might say that I am not aware of any tract which could be largely taken up by tube wells. The Hafizabad tract possibly might be worked by tube wells but there is no power available from the canal. The intensity of irrigation is already very high and if we increased it, it would simply mean that we should give more water for the area that is already being irrigated. We could hardly increase the area already being irrigated. The area that is already being irrigated as compared with our theoretical intensity is very high. Where, for instance, you have a theoretical intensity of 75 per cent and, we are already doing 95 per cent, there is only five per cent left to do. There are tracts on this canal where we are already doing as much as 120 per cent by *dofasli* crops. As to whether there is any objection from the irrigation point of view to increasing this intensity still further, I can only say that if I knew what it is going to lead to, I might be able to express an opinion. I do not know exactly what the bearing of the question is. I do not see what could be the objection from the irrigation point of view to increased intensity provided, of course, that it meant improved farming, and not an increase of water.

3570. (Mr. Henderson.) I have not been told by the *zamindars* that there has been any decrease in out-turns. I think that they are keeping up to about the original level. I do not think that even with improved methods of farming, intensity could be increased under present conditions. I think it has reached the fair working limit. If the present prices of cotton are maintained, there are indications that the area under it will increase at the expense of other *khari* cultivation. The increase might possibly be at the expense of wheat. I am not competent to give a figure as to what the increase might amount to in the course of a few years even at a guess.

* The present average daily supply may be taken at 8,000 cusecs running for 180 days, making a total for the crop of 1,440,000 cusecs. If instead of 180 days, 30 days the Canal was run in October for .

November	15
December	16
January	16
February	13
March	31
TOTAL	122 days.

the average daily supply required to be run would be $\frac{1,440,000}{122} = 11,800$ cusecs instead of 8,000 cusecs as at present. The present carrying capacity of the canal is 11,400 cusecs, so that a very slight increase on present carrying capacity would be required.

The increase on the present average daily supply would be $11,800 - 8,000 = 3,800$ cusecs or nearly 50 per cent increase on the present daily average.

Mr. E. S. LINDLEY.

[illegible]

Mr. E. S. LINDLEY, Executive Engineer, Lower Gugera Division, Lower Chenab Canal, Lyallpur.

Written statement.

VI.—IRRIGATION.

3579 (51) Wheat *versus* cotton.—There is to my mind no doubt that cultivators prefer wheat to cotton, for the following reasons:—

- (1) while the normal out-turn of wheat is more than double that of cotton, the normal price is also more than half, so that wheat is more profitable ;
- (2) in by-products too wheat is more valuable, *blusa* being of more value than cotton seed and stalks ;
- (3) wheat and *blusa* are more necessary to the *zamindar* than cotton, and more readily and certainly saleable ;
- (4) the cultivation of wheat calls for less labour, especially less manual labour than cotton ;
- (5) wheat is on the ground only for some five months, as compared with eight months for cotton ;
- (6) wheat is a less precarious crop than cotton ; the latter may be badly damaged by heavy rain, or boll-worm ;
- (7) wheat is less affected by temporary shortages of water ; it will give some return even with one watering after sowing, while cotton may fail entirely for want of one watering within a certain short period.

3580. (52) (a) Critical period in regard to water supply.—Taking the irrigation year beginning with the opening of the *kharif* season, on a perennial canal:—If *rabi* supplies have been poor, *rabi* demand may remain comparatively high till late, though it is doubtful whether really late waterings are not wasted; but as the early *kharif* crops are only something like half the *kharif* area, there is not much difficulty of supply at the worst. During *kharif*, there is ample water in the river, and the canal can carry an ample supply to cover even a failure of monsoon. But when a flood is passing the head-works, it may be necessary to close the canal for a time, because admission of silty water will cause silt difficulties. While in charge of the Rasul head-works, I did not find necessity there for long or frequent closures, even during the bad floods of 1916; I never heard of complaints of shortage of supply through such closures as I had to enforce; I had no silt trouble myself through possibly keeping the canal running when it should have been closed, and heard of none elsewhere on the canal. On this canal, the Lower Chenab, however, closures on account of floods are far more frequent and of longer duration; during the early months of the past monsoon I had to complain of interruptions of supply and ask whether these could not be reduced. I know enough of the Khanki head-works to realise that present conditions there are different from those at Rasul, and have also commented on the great amount of silt in my channels: but I am not familiar enough with Khanki to venture an opinion as to how and to what extent matters could be improved by changes of working, or of works: and I know that the question of silt control at Khanki has long had the consideration of the officers responsible for it, and it will be solved. The question is an engineering one, but the result is that if rains fail or are late in the plains, and if, at the same time, rains in the hills cause river floods, there is danger of shortage of supply on the Lower Chenab Canal during the period in which these conditions may occur.

(2) First *rabi* waterings are wanted while the last *kharif* waterings are still being given, and unless late rains have been good, there will be a beginning then of keen *rabi* demand; but, in my opinion, the whole *rabi* demand can be satisfied even with low minimum *rabi* supplies such as of 1915-16, by the system of rotational turns; and the only real difficulty is in getting supply to the tails of channels not fitted with some form of module. This year working has been greatly improved by the giving of permission to run as much as channels would carry, as long as supply was available, irrespective of the calculated allowances. As some members of the Committee may be unfamiliar with Indian irrigation and wish to follow the difficulty, I will try to explain it as simply and briefly as I can. The ordinary form of outlet, through which *zamindars* take their supply, is

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[Continued.]

a plain orifice ; the discharge of this depends not only on the fixed size of the orifice, but also on the variable difference between water-levels in our distributary and in their water-course ; by silt-clearing the water-course as much as is possible, they can draw more water. In this manner, the upper outlets on a distributary will always draw more than their share of water at times of keen demand—leaving less for those further down the channel : if supply in the distributary be increased, they will in general manage to draw more than their share of this too, and it is often impossible to run in a channel so much supply that what passes on suffices for those further down. While such outlets are in use, the only remedy is to close upper outlets that have done their irrigation ; but it hardly needs saying that such closures are difficult to enforce and lead to abuses ; the number of really responsible men on a canal being small, such closures are very difficult to arrange without unfairness. This is remedied in a number of channels on this canal by substituting a type of outlet that takes advantage of natural laws, and makes the discharge independent of water-level in the water-course : the policy of installing these outlets has been criticised ; the criticism seems to be in essence that this device is not perfect : I have not met one engineer who is using them, who does not consider them a vast improvement on the old type, as long as it is not assumed that they are a panacea, and require no attention to prevent tampering.

(3) In this division, such outlets have not been installed for long enough to make it possible to present complete and convincing figures. But I can quote one case of a distributary fourteen miles long, on which I had a series of discharges observed at different points, and found that Kennedy Gauge Outlets resulted in practically correct distribution all the way down. Another distributary, 25 miles long, used to be difficult to feed at the tail ; fitted with these outlets it is now being run with about five per cent over the calculated supply, and the excess is being distributed very evenly all the way down, the only complaint I have had from the tail being found ridiculous on personal investigation. Another distributary, 29 miles long, has always been a great difficulty, and though half the outlets had been converted, there had still been difficulty : this year ample supplies are reaching the tail with only some twenty per cent extra running at the head, after some drastic action with regard to interference with outlets. Other channels without, or with only a few gauge outlets, are being run with anything up to double the calculated supply, to get sufficient to the tail.

(4) The effect of an increased area under cotton is discussed in paragraph 3533.

3531. (52) (b) Watering of cotton.—I cannot add usefully to the information of more expert witnesses as to the watering of cotton. Two irrigation authorities, Mr. Berosford and Mr. Kennedy, have from entirely different data of different natures, arrived at three inches as the approximate depth of watering of a crop, as actually practised ; in any but the most uneconomical practice it cannot exceed $1\frac{1}{2}$ times that.

3532. (52) (c) Statistics.—As we do not record separate waterings, but only the area that has at any time had canal-water during the crop season, whether it has had one watering or ten, I cannot give monthly areas ; without this the other figures asked for are useless.

3533. (53) (a) Possibility of expansion of area under cotton by enlargement of canals.—The increase of cotton area can come about in either of two ways, either by substitution for *rabi* crops or for other *kharif* crops. In substitution for *kharif* crops, it would not seem likely that more cotton will be grown at the expense of grains, fodder, or cane ; but American cotton is already being substituted for *deshi* to an increasing extent. At present prices, cotton seems to have a chance of competing with wheat in popularity, and with any certainty of such prices continuing there might be a tendency to substitute.

(2) If American were substituted for *deshi* cotton, the situation during *kharif* would not be affected, but there would be an increase over present demand in February and in October for essential waterings : the February watering would, I think, be provided all right, partly by our improving winter distribution, and partly by *zamindars* giving less unessential waterings to wheat on having an alternative and greater need for the water. The need for the October watering (the cotton being on the ground) will, in years of poor monsoon and early fall of river supply, result in more wheat being left for late sowing, and possibly a decrease of wheat area ; but I think improving winter distribution would save this.

(3) If cotton (presumably American) were substituted for *rabi* crops, the February and October waterings would be given to the cotton instead of the *rabi* ; during *kharif* there would be an increase of demand, which would be met all right if the need to close this canal during floods were diminished. During *rabi*, the lesser wheat area would call for less water than at present ; and as supply is sufficient for present requirements, some could be available for extensions.

(4) I do not myself see the need for enlargement of the canal. There is very little room for increase of cultivation within the area served by this canal, and I think the same applies to the Lower Jhelum Canal : what extra water is wanted as above can be supplied by improved efficiency of canal working. When it is remembered that, taking all causes of loss and waste together, only about a quarter of the water taken from the river is usefully applied, it is obvious that the saving of absorption losses, and the securing of greater economy of water by *zamindars*, leaves room not only for all increase of useful supplies that can be wanted, but also for enormous extensions to now unirrigated tracts.

3534. (54) (a) Improvement in duty of water by remodelling of outlets.—I have already given my views on the utility of modules ; more increasing of size of outlets that are doing less well than others, and decreasing of those that are doing above the average, is an unsatisfactory and endless process. No channels in this division have been fitted completely with modules long enough to give any figures.

3535. (54) (c) Effect of remodelling of outlets in irrigated area.—The effect of, equalising distribution of supply will be a small increase of total area, possibly ten per cent, as the result of getting on tail outlets proportional irrigated areas equal to those of outlets higher on the distributaries : but the principal effect will be a saving of water at present given in excess on the upper outlets.

3536. (55) Fluctuations in river supplies and their effects.—While in charge of the Rasul Division, I prepared diagrams of the supply in the Jhelum river during the winter months for the past 25 years or so. I believe similar diagrams were prepared for the Chenab. The matter of gradual or sudden decrease is relative and depends on the conditions of the year. After the monsoon, the curve of supply is dropping at first faster and then more and more slowly : if the minimum to which supply is tending in any year is not much below the supply taken by canals on the river, supply will fall short of demand at a part of the curve at which the rate of decrease is slow, and the decrease would be described as gradual : in a year of low minimum the decrease would seem sudden.

(2) *Zamindars* cannot tell what the conditions of supply are going to be ; the monsoon of 1916 was heavy and yet winter supplies were distinctly below the average. I do not think the Indian *zamindar* looks very far ahead ; he plants as much as he can, if supply falls short, he bombards everyone with petitions and complaints, and makes the best of what the canal engineers can give him.

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[Continued.]

3587. (56) (a) Utilization of wells for irrigation of cotton in canal areas.—The inundation canal tracts that I know are not, in my opinion, suitable for cotton growing. The Corbynwah is on the right bank of the Jhelum, above Shahpur; the soil of the tract served is so salt and poor that little but grass irrigation is done. The Raniwah is on the left bank of the Jhelum about Bhera; the tract is a slightly depressed valley, separated from the river by a slight ridge; into this a number of privately managed inundation canals pour water, and moderately high river floods add their spills, so that the whole depression is water-logged and for most of many monsoons largely under water. The owners of the private canals have refused the terms offered them in connection with closing off the inundation canals and spills and substituting controlled supplies from the Lower Jhelum Canal.

3588. (56) (b) Extension of irrigation under wells in canal areas.—In the Raniwah tract, sufficient wells exist.

3589. (56) (c) Tube wells.—There is also a tract on the land side of the above valley, above flood level, but to which irrigation had not been extended from the Lower Jhelum Canal, in which sub-surface water is at a reasonable depth from surface: one land-owner had there installed a tube well, and I made some notes of its running which I can produce if wanted.

3590. (56) (d) and (e) Construction of weirs versus construction of wells.—I take it that what is meant is the construction of a weir such as is made for a big perennial canal for inundation canals. It is almost obvious that a considerable area is required to make a weir remunerative. The Corbynwah has far too small and poor an area for the suggestion of a weir to be contemplated for a moment; in fact, the whole right bank down to the point at which the proposed Sind-Thal canal is likely to take up irrigation, seems to be too narrow to afford sufficient area, and a canal needs many and expensive cross-drainage works. The Raniwah and all the other left bank canals can be taken over by the Lower Jhelum Canal.

3591. (57) Effect of enlargement of canals on revenue.—In paragraph 3583, I have expressed the opinion that there is no need to enlarge the present canals. I might add that the newer canals also have considerable reserve capacity. The Lower Gugera Branch now serves an area, the allowance of water for which at a cusec to 250 acres annual irrigation (annual irrigation being 75 per cent of the allotted area), plus allowance for absorption in distributaries and the Branch comes to 1,760 cusecs. The allowance for the whole area now commanded, and commanded by contemplated extensions, is 1,926 cusecs. The Branch has safely run 2,000 cusecs, and would safely run over more than that with only some strengthening of weak points: if run in the manner of some of the older canals, it could be increased by fifty per cent. on only strengthening of banks.

3592. (58) Cropping and causes affecting it.—In consultation with some of my assistant officers, I arrive at the following. We have, in essence, to consider the cultivator with a holding of one or of two squares; if a landowner has a larger holding, this will be divided into such holdings worked by tenants, he himself working a holding if he be a cultivator: the ordinary man works one square, but can work two with a larger family. Crops are divided into two classes, those grown for his own needs, and those grown for sale of the surplus above his needs; the needs of a household working two squares are not necessarily double those of a cultivator working only one square. In the case of *janglis*, habits and needs are so different that a different estimate is called for. In the case of cultivators, the areas are made to add up to 110 per cent which is the average proportion of actual annual cultivation to allotted area; and the actual proportion of *rabi* to *kharif* of 2: 1 is maintained. *Janglis* grow in *kharif* only the little grain and the fodder they want, concentrating more on *rabi* :—

	1 square.	2 squares.	Jangli.
Vegetables, spices and tobacco	2	1	...
Grains; <i>makki</i> and <i>bajra</i>	8	8	4
Fodder; <i>chari</i> and <i>juar</i>	8	6	16
Sugarcane	8	8	...
Cotton	8	11	4
TOTAL <i>kharif</i>	34	34	24
<i>Toria</i>	12	8	20
<i>Senji</i> , <i>sarshaf</i>	12	8	6
Grains, wheat, gram, etc.	52	60	60
TOTAL <i>rabi</i>	76	76	86
GRAND TOTAL	110	110	110

In *kharif*, the cultivator grows vegetables, etc., and fodder entirely for his needs; grain principally for his needs, selling any surplus; cane is most profitable and he puts down all he can work; the rest of the area is cotton. The *jangli* wants a little grain and much fodder; he wants a little cotton, but by flooding it liberally he grows a good crop of grass for his cattle.

(2) I think a *zamindar* will always sow as much as he can on the water he gets at sowing time, helped by rain. My impression is that good or poor supply in the river has little effect except on duty and delta (poor supply compelling better efficiency) and that area is affected principally by rain. I have never discussed rotations with *zamindars*.

(3) Unless there were a certainty of permanently better relative prices of cotton (as compared with wheat) and until that certainty is accepted by the Indian *zamindar*, I do not think an increase of cotton area at the expense of wheat is likely. The water that is available in the rivers in winter must be taken; I believe it to be a fact that a proposal to diminish water-logging by giving less water for irrigation in the tract affected

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[Continued.]

was vetoed; also that a proposal to reduce the supply of the Lower Jhelum Canal gradually to prepare for the reduction that would ensue on opening of the Upper Jhelum Canal was similarly vetoed: reduction will only take place when other canals are opened to share the supply and there will be strong opposition to any proposals to make such canals. In fact, I consider that demand does and will continue to rule supply to the extent that supply will not intentionally be altered with the idea of forcing a change of cultivation.

3593. (59) Practicability of lining canals.—I have no personal experience of the lining of canals. I should very much like to see a bold experiment tried of making a distributary of fair size, lined from the head to the fields with more regard to efficiency than cost of lining, modulated to a really economically low rate of supply so that there was an inducement to efficient irrigation: I believe the results would be surprising.

3594. (61) Enlargement and lining of canals.—Such ideas as I have are too revolutionary to be of any use as evidence before a Committee that is considering cotton: it seems as if present Indian methods, directed to providing the forms of lining so far used, could never make the progress needed for a really large and comprehensive scheme.

3595. (62) Effect of lining canals on seepage problems.—Since any lining will stop some percolation from channels; since percolation water very soon goes too deep to be absorbed by plants, and no evaporation of any magnitude from a depth has yet been established (the whole matter is one of which too little is known for any certain judgment), it can at least be said that percolation from a canal will raise the water-table in the tract. Raising of the water-table also increases the rate at which water flows away under the tract, and it is not at present possible to say of any tract whether the degree of rise of water-table at which the percolation will be balanced by increase of outflow will be sufficient to amount to water-logging. Where water logging has occurred, to decrease percolation will lower the water-table locally, though it may still be held up by a high water-table in the direction of out-flow of sub-soil water, so that the local lowering is slight. We have not yet the data on which we could even approximately calculate a specific case, much less estimate the value of the general benefit in an undefined case, for comparison with cost.

3596. (63) Effect of lining canals on supplies.—I have already given the opinion that no increase of supply is wanted in the tracts served by canals that I know; on the contrary, there are a number of reasons for limiting supply. Any saving by lining would therefore be available for new canals. I would also like to mention one aspect of the lining problem that seems in some danger of being lost sight of. It is estimated roughly that of every 100 cusecs taken in at canal heads, some 25 are lost by percolation in Government channels, some 25 more by percolation in private water-courses, some 25 more wasted by further percolation through water-courses being inefficient, by petty wastages, by inefficient or excessive irrigation; that only some 25 are usefully applied; or that in a water-tight system of channels serving zamindars who wasted nothing, a quarter of our present supplies would suffice. That is, to deliver the same quantity for irrigation, we should have to take in 75 cusecs at the head for every present 100 cusecs, if the whole Government canal system were lined fully; such lining as has been and is being done is in the upper reaches of canals and branches. Now say that the whole water-course systems were lined; if only the 25 cusecs of genuine percolation were saved, and none of what has been classed as waste, we should have to deliver at outlets fifty instead of 75 cusecs; percolation in Government channels accounting for a third of the quantity delivered, we should have to take in only 60½ cusecs at the head as compared with 75 cusecs as the result of lining canals. Similarly, if we were to induce such economy of irrigation that the 25 cusecs of waste were saved, we should still with unlined canals and water-courses, only have to take in fifty cusecs at the head. The contrast is increased if we subtract from each figure the 25 cusecs usefully applied, leaving 50, 31½, and 25 cusecs that is being added to the sub-soil water-table. The points to be made are two: first, that (apart from the difficulties of lining a big channel that has to be kept in flow, and the fact that measures further down the system leave it with too big a capacity) lining measures should be started from the bottom instead of the top of the canal system: second, that the quantities wasted justify a comprehensive scheme, and that a test as suggested in the answer to question 59 (paragraph 3593) is badly wanted, so that at least one canal scheme of those next to be constructed, may be built on such lines.

3597. (64) Suitability of water rates.—Canal water-rates being of the order of ten per cent of the net profits of crops I do not consider that they have the slightest effect on the zamindars' preference for particular crops. When a change of canal rates is suggested, a reduction is generally meant; I do not consider any reductions to be called for on such grounds as come within the purview of an irrigation officer.

Mr. E. S. LINDLEY called and examined.

3598. (Mr. Ashton.) Saving of loss by absorption is a distinctly technical question which has to be worked out weighing all aspects. In the first place, I think we should attempt to bring the *kharif* efficiency up to the *rabi* efficiency. I do not mean that the *kharif* delta, i.e., the depth of water applied should be brought down to the *rabi* delta but that it can be reduced. When that has been done, it seems to me that we should also have to consider the question of waterlogging in tracts in which it is becoming or has already become serious. The greater the intensity of irrigation in the tract, the more water you give for irrigation, the more water you pour into the tract. The amount wasted, the amount that goes down to the sub-soil table, is proportionate to the amount that is used in irrigation. If you add to that, you will increase the water-logging. We are running the full theoretical capacity now. I consider that to a small extent we could run an appreciably bigger supply by strengthening the weak places and cutting berms if there was a demand for it. We could run a bigger supply in April and May than at present. In April and May, there is a difficulty in running some of the channels because the demand is so low that we cannot run them properly. If we had a large increase in the demand in April and May, we should find the distribution very much easier and the channels could be run more efficiently than at present. We would rather have the channels running full for one month than half full for two months. That is the reason why we sometimes have closures in April. We sometimes find closures advisable when the demand is really very slack. We come down to days at times when we have to force water on some people because other people want it. At such a time it may be better to close down so as to stimulate demand. The zamindars do not keep their water courses as clean in the *kharif* season as they do in the *rabi* except in October when they are getting more water. At the sowing times, there are some short periods of demand, when some of them will clear their water courses. During the *kharif*, the water courses are left to themselves. If they kept their water courses as clean in *kharif* as they do in *rabi*, the upper outlets would give more water than they do at present. The fact that they do not do it,

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appears to show that, under present conditions, they do not want more water in *kharij*. In the *kharij* there is really little difficulty in forcing the supplies to the tails of the distributaries while in *rabi* there is great difficulty, especially on distributaries not fitted with modules. In fact this is a reliable means of gauging demand, and our statements of poor or keen demand are not based on mere opinion. Ordinarily in the *kharij*, you run a smaller discharge at the head and get a greater supply to the tails on the distributaries than you do in the *rabi*.

3599. I recommend lining both from the point of view of preventing waterlogging and also of making more water available at the critical period of irrigation. Water lost by absorption goes to the subsoil table. The use of modules is undoubtedly beneficial. I expect a small increase of irrigation from it by the tails of distributaries getting their proper supplies more easily and more certainly. At present, the irrigation at the tail ends of distributaries is somewhat restricted by the *zamindars* being uncertain of what they will get. Their supplies depend on the energy of the men working on the channels. My reasons for the arguments in paragraph 3583 of my written evidence are that there is no case for increasing supplies as my impression is that the amount of irrigation actually done is just about as much as could be done in the culturable area allotted and commanded. I have just seen a paper in which the case of Egypt is quoted and 200 and 300 per cent. intensities are talked of but the Indian cultivator is not like the Egyptian. He would not adopt such a high intensity as in Egypt. Also we hear that very large drainage schemes have been necessary in Egypt. Under these conditions, many intricate questions are coming up there. As a Divisional Canal Officer, I would welcome a greatly increased demand in the early part of the hot weather and if that demand continued up to October, I would meet it by strengthening the banks and by other improvements in the channels.

3600. I cannot say whether the Shalpur branch of the Shalpur district could be made a paying concern if those tracts which are served by Government inundation canals were taken up and the private canals were left out. It is a tract where there are limited possibilities of growing cotton and it is not grown at all at present because the inundation canals are opened very late. On the other hand, as long as the private canals are kept going, the tract will be flooded by river spills as now.

3601. (Mr. Roberts.) The statement in my written evidence that the normal outturn of wheat is more than double that of cotton, is based on general statements made to me and not on personal experience. I would consider the normal price of wheat as Rs. 2-8 to Rs. 3, and the yield to be twelve maunds and upwards. The normal price of cotton per maund is Rs. 4 to Rs. 5, and the outturn about six to eight maunds. If the price of cotton were Rs. 8 per maund, it would be more profitable than wheat. In the case of wheat, the *zamindar* looks also to his *bhusa*. He gets twenty maunds of *bhusa* which, at annas four to six per maund, is worth about Rs. 8. I admit that the statement in my written evidence is based on a lower price of cotton than that now prevailing. If the present high prices of cotton continued, it would make a tremendous difference but the *zamindars* have got to be satisfied with sufficiently high prices.

3602. I think that before anything much is done to increase the *kharij* supply, we ought to increase the *kharij* duty. Better use should be made of the water already supplied. The only time when a saving could be effected would be at the critical period, April and early May and September and October. There is no shortage of water in the middle period of the summer, especially if you could grow more fodder crops. If the idea is to grow more fodder crops, I think we have enough capacity to cover a considerable increase of area except at the critical periods which I have referred to. There are possibilities of saving in all directions. We should, of course, have to strengthen the weak parts of our channels. I do not consider that we could carry as much as twenty per cent more without strengthening the canals. As to carrying any more supply without strengthening, I can hardly speak with authority. My own branch is the Lower Gugera Branch. It has carried 2,000 cusecs against the 1800 to 1900 which it is expected to carry. It could carry ten per cent more.

3603. As to the accuracy of Kennedy's figures for loss by seepage, so far as the Government canal system is concerned, I believe they are approximately correct; I have not gone into the question deeply to see whether it is so or not. I think his estimate is 25 per cent. loss from head to outlet. In lining canals, I consider you would have to consider the question of the amount of water saved in conjunction with the use that would be made of it. Of course, if you are going to increase the intensity to 200 to 300 as in Egypt, you would be able to grow more fodder crops to increase the fodder supply. Increased intensity, leaving aside the question of lining, is bound to lead to greater waterlogging. It would accentuate the present evils which are already rather serious in some parts. My own observations confirm that 25 per cent of the water is lost in the water-courses and another 25 per cent is lost in avoidable ways such as waste and inefficiency. The Canal Department is continually improving and the *zamindars* on this canal work better than on the older canals. I believe Kennedy's observations were with reference to the older canals. Here we have divided the area into villages according to the natural configuration of the ground. In the older canal tracts all sorts of boundaries were fixed so we had to make longer water courses. It is probable that the loss is less on the new canals than on the older ones, and that they are more efficient in this respect.

Mr. A. R. MURRAY, Superintending Engineer, Derajat Circle, Punjab.

EXAMINED AT LYALLPUR, JANUARY 14TH 1918.

Written statement.

VI.—IRRIGATION.

3604. (50) Experience.—I have had some experience of irrigation, including assessment work, on the following canals of the Punjab:—Western Jumna, Sirhind, Lower Chenab and Derajat, but I confine my remarks mainly to the last mentioned.

3605. (51) Wheat *versus* cotton.—It has been my experience that cultivators prefer wheat to cotton as an irrigated crop for the following reasons:—

- (i) It is a food and fodder crop.
- (ii) It is a safer crop and less sensitive to drought, cold, heat storms and attack by insect pests.
- (iii) Its market is more stable.

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- (iv) It requires less water.
- (v) It is cultivated at a time when climatic conditions are less trying.
- (vi) It is said to be more profitable on the average.

3606. (52) (a) **Critical period in regard to water supply.**—The canals of the Derajat come under the classification of Inundation Canals. Irrigation is, in the main, effected during the hot weather months, when the rivers Indus, Chenab, Ravi and Sutlej, are in flood. With the exception of the modern Sidhni Canal, none have off-takes above river weirs (as a general rule, the Ravi at the point of off-take of the Sidhni dries up entirely during the winter). All the other canals are dependent for their supplies on the natural water surface levels in the rivers at the points where their heads are located. These levels are subject to considerable fluctuations. The critical periods are April and May, the latter part of September and October. If a large area of cotton did happen to be sown at the commencement of the irrigating season, September and October would be the critical period. During July and August, we can count on ample supplies: in fact, water is often received to excess. Canal irrigation during the critical periods mentioned cannot invariably be guaranteed and this absence of guarantee is the chief factor militating against extension of cotton cultivation in the tracts commanded.

(2) I attach diagrams (Annexures IV—VII)* to illustrate the water supplies received in the Sidhni Canal and the Sikandarabad, one of the older canals, during April, May, June and September and October for years 1912-16. I have also quoted figures of area of cotton matured. By comparison of the diagram and area figures for 1914 with those of 1916, it will be seen what a marked effect the conditions of water-supply have on the cotton area, and the remarkable extent to which variations do occur.

3607. (52) (b) **Watering of cotton.**—As a general rule, the field is watered once in May or early June to a depth of about six or seven inches before sowing the cotton. The next watering is given about the end of June or beginning of July and thereafter one watering at intervals of about fifteen to twenty days until October. The depths of these waterings are about five inches. The intervals between waterings depend largely on weather conditions. If the hot wind blows, cotton may require water every seven days. Frequently half an acre to two acres of cotton per well are started from well waterings in April.

(2) The tracts commanded by the Derajat canals are dry and rainless and the cultivators are backward in their methods in regard to the economical usage of water and tillage generally. Long-staple cotton has only just been introduced in the Circle. 743 acres are reported from the Sidhni Canal for 1917. Most of this was sown on canal water received at the end of May and early June. It is reported to have done well and to have withstood the abnormally wet conditions of the past monsoon better than the *deshi*, but I have been unable to obtain any figures of out-turn. Pir Bakhsh, *zamindar* of Buch, Multan, estimates an out-turn of ten and a half maunds per acre of American cotton sown by him in March 1917, on three acres, by means of well water and matured by canal. The fields were well manured prior to sowing. He is favourably impressed with the result and will do more next year.

3608. (53) (a) **Possibilities of expansion of area under cotton by enlargement of canals.**—Enlargement of the canals of the Derajat Circle would not overcome the difficulty of securing early and late supplies, more especially early supplies, and no large expansion of the area under cotton can be looked for by increasing capacities.

(2) In regard to canals in general, before any such drastic innovation as enlargement can be contemplated with the object of pushing the cultivation of long-staple cotton, it would seem that one of the two following conditions must be satisfied:—

- (i) that a supply of water, in excess of the maximum which the canal is now capable of carrying, can be assured in the river at equal off-take during April; or
- (ii) that the present demand for water during April is in excess of that which the canal can now carry.

The Western Jumna Canal is an example of a canal in which condition (i) is not satisfied and the Sirhind and Lower Chenab Canals are examples of canals in which condition (ii) is unsatisfied. Any enlargement of canals with the object of securing extra supplies during February, would, in my opinion, be futile, as river supplies, in excess of the carrying of the canals, cannot be assured at that season.

3609. (54) (a) **Improvement in duty of water by remodelling of outlets.**—It is difficult to say to what extent the duty of water on the Derajat canals can be improved by equalising the distribution of supply between the upper and lower outlets. On the Upper Bari Doab Canal, the *kharij* duty for the years 1893 to 1895 averaged 69, for the years 1913 to 1915 the average rose to 98, an increase of forty per cent, presumably as a result of remodelling. On the canals of the Derajat, a certain amount of remodelling has been done and is being done, but I consider that, other things being equal, we may reasonably expect an improvement of about twenty per cent. from further scientific remodelling and that the area under cotton will expand in the same ratio.

3610. (54) (b) **Utilization of modules.**—It is impossible to say, in the absence of practical data, to what extent modules or gauge outlets would improve the duty. It can only be said that their effect would certainly be beneficial, especially during periods when water-supply is tight. Modules have not been introduced up to date in the Derajat Circle.

3611. (55) **Fluctuations in river supplies and their effects.**—The increase in spring and decrease in autumn of the rivers, with which the Derajat canals are concerned, are generally speaking gradual. The rate of increase or decrease does not, in my opinion, affect the cultivators, preference for any particular crops. That is dependent on the extent to which increase and decrease take place at critical times. If the rise were early and rapid, an impetus would be given to the cultivation of cotton and indigo.

3612. (56) (a) **Utilization of wells for irrigation of cotton in canal areas.**—It is possible, in the tracts commanded by the Derajat canals, for sowings and final waterings of cotton to be carried out to a small extent by irrigation from wells. As a general rule, cultivators prefer to await the arrival of canal water before sowing, but it is a fairly common practice to sow half an acre to two acres per well by the aid of well water. It is possible that the cultivators may be encouraged to extend this area to four acres per well but this is considered a maximum figure. There seems to be an impression that the high current market rate for cotton is only temporary and will not be maintained.

3613. (56) (b) **Extension of irrigation under wells in canal areas.**—I attach a statement (Annexure I) to show the extent to which wells exist in the tracts commanded by the canals of the Derajat, and the extent to which the number has increased since settlements.

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ANNEX

Statement showing culturable areas commanded, areas irrigated and matured, areas of cotton

Name of Canal Series.	Culturable areas commanded in acres.	Areas irrigated (upper figures) areas matured (lower figures.)					Percentage of areas irrigated on culturable area commanded.					Areas of cotton matured.				
		1912-13.	1913-14.	1914-15.	1915-16.	1916-17.	1912-13.	1913-14.	1914-15.	1915-16.	1916-17.	1912-13.	1913-14.	1914-15.	1915-16.	1916-17.
Chenab Series . Jalandhar Division.	401,603	249,269 191,874	254,705 223,055	331,659 304,702	270,150 223,249	298,556 249,894	62.1	63.4	82.0	07.3	74.3	30,447	27,830	50,750	22,022	3,398
Chenab Series . Jalandhar Division.	380,552	184,056 130,705	190,935 171,345	210,338 194,218	170,485 141,852	205,075 180,724	48.4	51.8	57.7	44.8	53.9	14,008	25,777	25,177	9,004	12,224
Lower Sutlej Series Jalandhar Division.	768,570	246,872 200,735	233,127 265,621	371,059 347,483	283,572 241,813	363,884 320,613	32.	30.8	48.0	36.8	47.3	12,914	27,882	32,230	7,034	9,065
Chenab Series . Jalandhar Division.	600,472	249,188 175,484	245,704 198,131	223,892 157,298	235,041 182,029	265,168 203,380	37.7	37.2	33.8	135.0	40.1	28,029	13,370	25,436	11,994	16,184
Chenab Series . Jalandhar Division.	639,552	385,365 356,402	375,739 344,028	378,044 325,703	377,395 351,984	398,458 370,072	60.3	58.7	59.2	59.3	62.3	36,101	34,320	23,668	13,602	2,543

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ANNEXURE II.

Statement showing culturable commanded area with average area matured and area proposed to be irrigated by the Haveli Weir Project.

Name of canal or area.	Culturable commanded area.	Average area irrigated for 14 years 1000-01 to 1913-14.	Average area matured for 14 years 1000-01 to 1913-14.	Area proposed to be irrigated by the Project at 60 per cent.	Probable improvements on matured areas, column 5 minus column 4.
1	2	3	4	5	6
Left Feeder new area (Jhang)	165,490	...	...	98,784	98,784
<i>Sidhnai Series.</i>					
Sidhnai Canal	318,399	196,209	150,763	196,209*	45,446
Fazilshahi	32,730	14,108	10,531	19,638	9,107
Karanga	3,800	8,104	5,889	21,500	15,611
TOTAL	380,929	218,421	167,183	237,347	70,164
<i>Chenab Inundation Series.</i>					
Matthul	17,000	8,561	6,901	10,200	3,303
Wali Muhammad	193,316	83,315	62,619	119,589	56,970
Sikandarabad	150,231	81,039	64,219	90,138	25,910
TOTAL	360,547	172,935	133,729	219,927	86,198
<i>Muzaffargarh Canals.</i>					
Right feeder new area	17,482	...	...	101,685	104,685
Karam Canal	19,004	7,293	6,272	11,402	5,103
TOTAL	193,486	7,293	6,272	116,087	109,815
GRAND TOTAL	1,112,002	398,559	307,184	672,145	364,961

* This is actual average irrigated and is something over 60 per cent.

ANNEXURE III.

Derajat Circle.

Statement showing approximate area of each crop irrigated per 100 acres culturable commanded area based on statistics for years 1913-14, 1914-15, and 1915-16.

Name of Crops.	Sidhnai Series.	Chenab Inundation Series.	Lower Sutlej Series.	Muzaffargarh Series.	Indus Series.
<i>Khurif Crops</i>					
Sugarcane	0.1	0.4	...	0.8	0.2
Rice	3.7	3.0	0.2	8.0	8.7
Cotton	10.1	5.7	3.4	4.1	4.3
Indigo	0.1	1.0	0.7	0.6	0.3
Juar	5.5	2.1	4.7	1.2	4.1
Maize	0.5
Bajra	2.2	...
Miscellaneous	12.2	10.0	9.2	4.8	4.4
TOTAL	32.2	22.2	18.2	21.7	22.0

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ANNEXURE III—continued.

Statement showing approximate area of each crop irrigated per 100 acres culturable commanded area based on statistics for years 1913-14, 1914-15, and 1915-16.

Name of Crops.	Sidhnai Series.	Chenab Inundation. Series.	Lower Sutlej Series.	Muzaffargarh Series.	Indus Series.
<i>Rabi Crops.</i>					
Wheat	28.3	20.1	17.2	25.0	8.4
Barley	1.1	0.5	0.5	1.2	0.3
Gram	4.3	...		4.0	1.6
Miscellaneous	8.4	7.8	...	6.1	1.9
Sarson	0.8	...	6.9
TOTAL	42.9	28.4	26.6	36.3	12.2

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for nearly 25 years, and have been in Divisional charge for nearly eleven years. The detail of my services is as follows:—

1893—1898 in the Ludhiana Division of the Sirhind Canal.

1898—1903, Lower Chenab Canal.

1904—1905, Sidhnai Canal.

1905—1911, Sirhind Canal.

1912 to date, Lower Chenab Canal.

3635. *General conditions of tenure, land revenue, and water rates on the Lower Chenab Canal.*—By far the greater portion of the area, irrigated by the Lower Chenab Canal, consists of what was Government waste and granted to Colonists from various districts in the Punjab, and to the local nomad or *jangli*; and by far the largest percentage of holdings are peasant holdings of one square of 28 acres, and some half square holdings; here and there, there are yeoman and capitalist grants of five squares and upwards.

(2) The land revenue assessment is "fluctuating;" that is to say, the cultivator pays revenue only on the area he cultivates, and nothing on fallows; the revenue rate is highest for canal irrigated land, then for well irrigated and lowest for what is matured on rainfall. No differentiation is made with respect to the crop sown.

(3) Canal water rates are also "fluctuating" and the cultivator pays according to the area irrigated and the crop cultivated. There are various rates of water rate.

3636. *Analysis of crops grown on various canals.*—I submit the following tracings (Annexures IV—X.)*

1. Diagram of the Rise and Fall of the River Chenab, 1915-16, at the Alexandra Bridge (Annexure IV).

2. Diagram of the Rise and Fall of the River Ravi, 1915-16, below the Sidhnai Dam (Annexure V).

3. Water consumption diagram of the Lower Chenab Canal for 1915-16. (Annexure VI).

4. Diagram showing the duration and amount of supply in the Sidhnai Canal for 1915-16. (Annexure VII.)

5. Working record of the Lower Chenab Canal, 1915-16. (Annexure VIII.)

6. Working record of the Lower Jhelum Canal. (Annexure IX.)

7. Diagram comparing the percentages of the chief crops irrigated by various canals in the Punjab during the year 1915-16. (Annexure X.)

(2) An inspection of Annexure X will show that the following percentages of the annual areas irrigated were under cotton:—

	Per cent.
I.—Western Jumna Canal	13.8
II.—Sidhnai Canal	11.3
III.—Lower Bari Doab Canal	11.0
IV.—Upper Bari Doab Canal	9.2
V.—Lower Chenab Canal	8.4
VI.—Lower Jhelum Canal	3.8
VII.—Sirhind Canal	Nil.
VIII.—Upper Chenab Canal	Nil.

(3) I am unable to explain why the Lower Bari Doab Canal stands so high on this list. It is a new canal, much of the irrigable area is unallotted, so that there must be considerable surplus water in the *rabi*; and where such exists the figures for the other canals show that the preference of cultivators is to increase the area under wheat and oil-seeds; this is particularly noticeable in the case of the Upper Chenab Canal, another new canal with water to spare, which grows no cotton at all. The case of the Sirhind Canal is different, the hot sand storms in May and June batter and scorch the young cotton plants, so that cotton does not find favour. I also think the soil is unsuitable. The Sidhnai Canal stands high on the list, but considering that though it receives a very heavy supply during the cotton season and none whatever during the wheat season, except for a first watering, still 59.5 per cent. of the irrigated area is put to wheat and food grains, I think that this distinctly points to a marked preference for grains. Again, on the Lower Jhelum Canal, on which the conditions are very much the same as on the Lower Chenab Canal, the percentage of area under food grains and oil-seeds is very high and that under cotton very low. This canal has hitherto had a very good supply during the winter season, and cultivators take the opportunity to put in large areas under wheat and oil-seeds, which they evidently prefer to cotton. I am of opinion now that the Lower Jhelum Canal will get a less liberal supply owing to a portion of the Jhelum River supply being required for the new canals, that the percentage of area put under cotton will increase.

(4) In general, my opinion is that an increase of the cotton area will not follow an increase of canal water, but a decrease. It is only when the canal supply is so reduced as to make it hazardous to mature large wheat and oil-seed areas, that cultivators will fall back on cotton to fill the land thrown out of wheat.

3637. *Analysis of cultivated areas of different classes of cultivators.*—Attention is invited to Annexure I and to the diagrammatic representation of the same in Annexure I. I should like to say that the selection of villages has been made entirely at random; all are favourably situated as regards water-supply. The results are curious and will occasion some surprise. *Mauzas* 191 and 195 are cultivated by *janglis* or *bar* nomads; these people have the reputation of being poor cultivators. The figures in the statement show that they grow in normal years about 2.60 times as much cotton as the infinitely better cultivator, the *kamboh* of *Mauza* 284, and about the same as the *safed posh* or yeoman of *Mauza* 363, and while the effect of the war has been to reduce the area under cotton (including melons) in the *jangli* villages by only thirteen per cent., the area in *Mauza* 284 has fallen by 55 per cent. and in *Mauza* 363 by 38 per cent.

(2) As regards the water allowance, the *jangli* villages receive twelve per cent. less water than either of other two. This difference is due to the fact that while non-*jangli* villages receive water at a certain rate to irrigate 75 per cent. of the holding, *janglis* receive water at the same rate to irrigate only 66 per cent. of their holdings.

(3) If water were the only variable factor, it seems obvious that those who receive least water cultivate the most cotton.

(4) I should like to record that, so long ago as 1912, I noticed that the villages on the Bhowana Branch, which are all colonised by *janglis*, grew practically nothing but American cotton, whereas the non-*jangli* grew only *deshi*. The cotton produced by the Bhowana Branch *janglis* is marketed in Jhang.

* Published in separate volume of maps and plans.

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(5) An inspection of the diagram and statement will show that the *jangli* grows a great deal of fodder. In addition to what is shown as fodder, he feeds the *juar* stalks to his cattle, also a portion of the wheat in its green state and lastly along with his cotton he almost invariably grows the pulses, *moth* and *mung*, as green feed for his cattle. In this case only cotton (the higher rated crop) pays water rate so that the *moth* and *mung* are free. This fact is probably one of the factors that acts in influencing the *jangli* in favour of cotton.

(6) Finally, while the non-*jangli* has fifteen per cent. of his area under *toria* and six per cent. under sugarcane, the *jangli* has only three per cent. under *toria* and ten per cent. under turnips (*sag*), so that the *jangli* is behind in these crops to the extent of eight per cent. and he uses the water in growing an additional three per cent. of wheat and has enough to give cotton the late waterings which it wants. I believe if the *jangli* were not a dairyman he would not grow so much cotton.

3638. *Preference for wheat and oil-seeds.*—I think all the statistics I have put forward show that cultivators have a marked preference for wheat and oil-seeds. The reasons for this are many—

(1) Difficulties in connection with cotton cultivation.

(2) Capriciousness of the market from the producer's point of view.

As regards (1), wheat is easily grown and easily harvested and it is free from diseases and pests. On the other hand, cotton wants constant attention during the hot months of the year, the harvesting is a laborious process, and the boll-worm is a nightmare. But all these troubles would be set aside, if the average return from cotton was as satisfactory as that from wheat. This brings me to—

(2) Capriciousness of the market from the producer's point of view. It is hardly necessary for me to lay stress on the point that there is no comparison between the prices of wheat and those of cotton from season to season; while the former has been stable and rising for some years, the latter has been subject to violent fluctuations, and the cultivator, who, though he may be illiterate, is remarkably shrewd, prefers a certainty to a gamble. He spends no money on implements, etc., for special crops; thus he is unfettered to turn to any crop that may show prospects of a good return. This versatility makes him a person to be respected. I believe the solution of the problem the Committee has set out to solve lies here. If the *zamindar* is not treated well in the matter of prices, his counter attack in the following season may be taken as a foregone conclusion.

3639. *Rotation of crops, and an answer to the question, "Are Lands idle and available for further cropping?"*—In Annexure XII I have endeavoured to represent the actual rotation that has been followed by certain typical cultivators. I myself am not able to offer an opinion as to whether the rotation was suitable or not. As regards the intensity of cultivation the diagram speaks for itself.

(2) I omit an analysis of the squares from *safed posh* village, as the holdings of which they form part consist of five squares each and no useful purpose would be served by analysing the crops produced in a part of the holding only.

(3) The analysis of crops in the square of *Mauzas 191 and 284* is as follows:—

Mauza 191, Cultivator Jangli.

	Per cent.
Percentage of holding cultivated in <i>rabi</i>	74
Percentage of holding cultivated in <i>kharif</i>	42

So that he cultivates 116 per cent. of the holding during the year, or sixteen per cent. is double-cropped while the area he is supposed to irrigate during the year is only 66 per cent. of his holding.

Mauza 284, Cultivator Kamboh Sikh.

	Per cent.
Percentage of holding cultivated in <i>rabi</i>	86
Percentage of holding cultivated in <i>kharif</i>	28

The *Kamboh*, therefore, cultivates 114 per cent. of his holding during the year, fourteen per cent. is double cropped, while the area he is supposed to irrigate during the year is only 75 per cent. of the holding. It is clear, therefore, that the man with the larger supply concentrates on the *rabi* rather than on the *kharif*; further, that both classes of cultivator already make excellent use of their land.

3640. *The effect of water-rate on cotton growing.*—The water-rates prevailing on the Lower Chenab Canal are as follows:—

	Per acre.
	Rs. A. P.
I.—Sugarcane	7 8 0
II.—Rice	6 4 0
III.—Melons (including cotton growing with it)	5 0 0
IV.—Cotton, oil-seeds, wheat, barley, oats, maize, winter fodder crops	3 12 0
V.—Summer fodder crops and gram	2 8 0

Lift irrigation is half the above rates.

3641. *Water-rate fluctuations.*—Since the opening of the canal these rates have prevailed. They have never been enhanced to correspond with the increased profits accruing to the cultivator. The only change has been in the opposite direction and 109 villages pay a reduced fourth and fifth class water-rate.

3642. *Land revenue fluctuations.*—Land revenue has been enhanced as below:—

	Per acre.
	Rs. A. P.
In 1892-1900 it stood at	1 4 0
In 1901-1902 it stood at	2 4 0
In 1903-1906 it stood at	2 7 0
In 1906-1912 it stood at	2 4 9

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[Continued.]

Since 1912 the new assessments have come into force and the land revenue varies from Rs. 2-4-0 per acre to Rs. 7 per acre.

3643. *Specific cases of land revenue enhancement and its effects on cotton growing.*—For the purposes of comparison two villages on the Rakh Branch have been selected. They are typical of conditions on the Rakh Branch; as a general rule the land revenue is lighter elsewhere. In both *Mauzas* No. 208 and No. 273, the land revenue demand was raised from the *rabi* crop of 1912-13 by about 230 per cent. It will be seen from the Annexures II and III that even this enhancement of land revenue had no effect on the area put under cotton, which did not decline until the outbreak of war, even so a recovery was made in the *kharif* of 1917. This bears out my opinion that rates do not have any effect, provided the crop matures and the cultivator gets a fair price for his cotton. Both land revenue and water-rate are paid by the cultivator to Government and he does not bother about how much goes to one Department and how much to the other.

3644. *Utility of modules.*—It is perhaps a little early yet to speak definitely on the effectiveness of modules. But I think if a suitable device is used and the distribution of supply equalised, the annual area of irrigation could be enhanced by not less than five per cent.; that is to say, by one million acres—but assuming the present market conditions do not change, I think, the increase under cotton would be only *pro rata*, that is by 84,000 acres, producing a water-rate of Rs. 3,15,000.

3645. *Construction of weirs.*—I consider it extremely bad irrigation practice to construct weirs, with the object of commanding isolated blocks of high land; such practice leads to nothing but trouble, breaches and water-logging, but by far the worst evil, that such devices result in, is that the channel so treated loses working head at the off-take, and it cannot take its full discharge except when the feeder is running full supply; a defect which not only seriously handicaps the cultivators of the high land, but also all those who did quite well without the weir. For the irrigation of high isolated tracts, the wiser course is to adopt lift irrigation, but the water-rate for this class of irrigation should be a graduated rate according to the extent of lift and not be uniform as at present (half-flow rate).

Punjab.]

Mr. C. G. May.

[Continued.]

ANNEXURE I.

Statement of areas irrigated by crops in village numbers 191, 195, 284 and 363 on Sultan Pakhra, Ghapni, and Gojra Distributaries for the three years ending 1916-1917.

Name of crops.	MAUZA No. 191, RAJBANA SULTAN PAKHRA.				MAUZA No. 105 RAJBANA SULTAN PAKHRA.				MAUZA No. 284 GHAPNI DISTRIBUTARY.				MAUZA No. 363 GOJRA DISTRIBUTARY.				REMARKS.				
	Class of cultivator Jangli (Bar-Nomad).				Class of cultivator Jangli (Bar-Nomad).				Class of cultivator Kambah-Sikh.				Class of cultivator Safaiyash or Yomani.								
	Percentage.	1915-16.	Percentage.	1916-17.	Percentage.	1915-16.	Percentage.	1916-17.	Percentage.	1914-15.	Percentage.	1915-16.	Percentage.	1916-17.	Percentage.	1914-15.		Percentage.	1915-16.	Percentage.	1916-17.
	1914-15.				1914-15.				1914-15.				1914-15.					1914-15.			
Wheat	540	45	518	47-6	476	42-5	471	48-1	510	51-0	475	41-0	515	40-0	493	42-3	838	46-8	837	47-6	
Barley	8	..	13	1-2	15	1-4	11	1-2	9	1-0	5	..	10	1-0	6	..	14	..	11	..	
Rice	1	..	9	..	35	3-2	34	3-3	5	..	..	..	..	..	..	..	..	..	..	1
Maize	10	1-4	27	2-5	17	1-6	26	2-7	14	1-4	43	3-7	52	4-7	58	4-9	36	5-0	105	5-8	
Oats . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mixed grain . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Great millet	95	7-9	32	3-0	84	7-5	78	8-0	106	10-6	..	..	..	..	..	..	..	..	..	..
Spiked millet	5	..	1	..	11	1-3	..	..	1	..	..	..	..	..	..	..	..	..	..	..
Gram	28	2-3	30	3-6	14	1-3	6	..	38	3-6	61	5-8	45	4-1	48	4-0	98	5-5	36	5-0	
Lentil . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Rawan	4	..	1	..	1	..	..	..	3	..	1	..	..	..	1	..	1	..	4	..
Mung . . . . .	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Moth . . . . .	..	..	6	..	..	..	..	..	..	..	..	..	..	..	16	1-0	11	..	..	..

Punjab.]

Mr. C. G. MAY.

[Continued.]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400	401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500	501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700	701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800	801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000	1001	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	1015	1016	1017	1018	1019	1020	1021	1022	1023	1024	1025	1026	1027	1028	1029	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	1041	1042	1043	1044	1045	1046	1047	1048	1049	1050	1051	1052	1053	1054	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1065	1066	1067	1068	1069	1070	1071	1072	1073	1074	1075	1076	1077	1078	1079	1080	1081	1082	1083	1084	1085	1086	1087	1088	1089	1090	1091	1092	1093	1094	1095	1096	1097	1098	1099	1100	1101	1102	1103	1104	1105	1106	1107	1108	1109	1110	1111	1112	1113	1114	1115	1116	1117	1118	1119	1120	1121	1122	1123	1124	1125	1126	1127	1128	1129	1130	1131	1132	1133	1134	1135	1136	1137	1138	1139	1140	1141	1142	1143	1144	1145	1146	1147	1148	1149	1150	1151	1152	1153	1154	1155	1156	1157	1158	1159	1160	1161	1162	1163	1164	1165	1166	1167	1168	1169	1170	1171	1172	1173	1174	1175	1176	1177	1178	1179	1180	1181	1182	1183	1184	1185	1186	1187	1188	1189	1190	1191	1192	1193	1194	1195	1196	1197	1198	1199	1200	1201	1202	1203	1204	1205	1206	1207	1208	1209	1210	1211	1212	1213	1214	1215	1216	1217	1218	1219	1220	1221	1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Punjab.

Mr. C. G. May.

[Continued.]

ANNEXURE II.

Statement of water-rate and land revenue assessed and area sown under cotton crop by crop for the last ten years ending kharif 1917 in Mauza No. 208, Raich Branch, Lower Chenab Canal.

[illegible]

Punjab.]

Mr. C. G. MAY.

[Continued.]

ANNEXURE III.
Statement of water-rate and land revenue assessed and area sown under cotton crop by crop for the last ten years ending Kharif 1917 in Mauza No. 273, Rakhi Branch, Lower Chenab Canal.

Particulars.	Rabi, 1907-08.	Kharif, 1908.	Rabi, 1908-09.	Kharif, 1909.	Rabi, 1909-10.	Kharif, 1910.	Rabi, 1910-11.	Kharif, 1911.	Rabi, 1911-12.	Kharif, 1912.	Rabi, 1912-13.	Kharif, 1913.	Rabi, 1913-14.	Kharif, 1914.	Rabi, 1914-15.	Kharif, 1915.	Rabi, 1915-16.	Kharif, 1916.	Rabi, 1916-17.	Kharif, 1917.
	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Water-rate	Rs. 4,116	Rs. 2,610	Rs. 4,806	Rs. 2,784	Rs. 4,915	Rs. 2,693	Rs. 4,975	Rs. 2,971	Rs. 4,067	Rs. 3,090	Rs. 4,709	Rs. 2,731	Rs. 4,769	Rs. 2,553	Rs. 4,737	Rs. 2,405	Rs. 4,327	Rs. 2,422	Rs. 4,566	Rs. 2,585
Land revenue	2,404	1,250	2,945	1,299	2,924	1,207	2,991	1,236	2,305	1,099	8,539	3,964	8,591	3,725	8,746	3,301	7,009	3,397	8,212	3,708
TOTAL	6,610	3,860	7,751	4,083	7,730	3,935	7,968	4,107	7,272	4,158	13,248	6,535	13,300	6,278	13,483	5,826	12,290	5,810	12,718	6,293
Area under cotton and melons .	..	Acres. 63	..	Acres. 42	..	Acres. 52	..	Acres. 123	..	Acres. 97	..	Acres. 93	..	Acres. 119	..	Acres. 71	..	Acres. 56	..	Acres. 88
Paying enhanced land revenue.																				

Punjab.]

Mr. C. G. MAY.

[Continued.

3654. As an irrigation officer, I do not see any objection to a higher intensity of cultivation. The economics of higher intensity should be worked out by experimenting on a particular distributary. It would be comparatively simple to arrange for higher supplies in the summer season on such a distributary.

3655. As regards the provision of weirs on inundation canals, I do not think it is practicable from the money point of view. The number of weirs required would be too great. Generally speaking I cannot see any objection from the engineering point of view. It would stabilise supplies at the beginning and end of the season.

Punjab.]

Mr. C. G. MAY.

[Continued.]

ANNEXURE I.

Statement showing irrigation on Direct outlets Darsana Branch illustrating the effect of installing Kennedy Gauge outlets in 1914.

RABI IRRIGATION.													AREAS.		ORDINARY PIPE OUTLETS.												STEEL TUBES IN PART.				KENNEDY GAUGE OUTLETS.				REMARKS.
Serial No.	R. D. of outlet.	Side.	Annual Permissible.		1890-1900	1900-01	1901-02	1902-03	1903-04	1904-05	1905-06	1906-07	1907-08	1908-09	1909-10	1910-11	1911-12	1912-13	1913-14	1914-15	1915-16	1916-17													
			Allotted.	Annual Permissible.																															
1	1,143	R	250	105	175		148	150	130	105	167	199	167	177	189	183	105	100	151	161	178	201													
2	5,165	R	280	210			171	107	204	275	185	255	224	224	222	261	520	101	129	139	210	206													
3	5,850	L	473	354	264		332	305	291	332	311	418	353	316	377	292	309	303	328	325	310	320													
4	5,804	R	400	300			292	260	158	207	234	315	292	300	310	300	291	218	152	204	287	372													
5	12,571	R	205	198			105	100	130	144	160	220	189	100	190	199	202	212	203	206	225	171													
6	15,203	L	200	190	75		105	102	137	183	137	247	206	212	213	211	205	143	184	193	182														
7	16,786	L	448	336	278		339	332	382	311	349	340	243	293	290	231	273	239	180	227	196														
8	10,912	R	213	150			291	92	139	139	90	151	135	138	135	165	127	139	139	129	130														
9	18,310	R	255	191	37		291	164	164	223	219	229	198	172	194	194	181	185	185	187	183														
10	21,758	R	439	329			453	402	353	344	312	447	373	334	352	343	312	303	333	278	180														
11	21,897	R	575	431	295		453	402	353	344	312	447	373	334	352	343	312	303	333	278	180														
12	22,095	R	707	507	300		450	371	473	517	411	491	391	378	399	401	388	339	348	270	333														
13	27,000	R	823	392	258		603	323	385	377	403	405	419	491	506	530	547	105	492	511	600														
14	31,010	R	504	423	182		381	292	318	287	383	403	419	491	506	530	547	105	492	511	600														
15	33,170	R	335	251				292	318	287	383	403	419	491	506	530	547	105	492	511	600														
16	38,330	R	540	405	21		337	407	402	370	393	403	419	491	506	530	547	105	492	511	600														
17	39,133	R	540	405	21		337	407	402	370	393	403	419	491	506	530	547	105	492	511	600														
18	42,754	L	259	194	287		159	173	172	370	380	175	280	332	217	193	225	212	237	231	290														
19	49,699	L	638	359	550		727	167	740	680	371	423	337	333	310	331	136	134	330	371	390														
20	50,800	L	408	463			338	354	354	400	431	359	354	359	353	331	311	291	213	273	320														
21	52,800	R	138	103	268		93	158	102	341	431	359	354	359	353	331	311	291	213	273	320														
22	53,300	L	471	333	682		546	201	517	604	607	423	354	359	353	331	311	291	213	273	320														
23	57,400	L	488	300	215		243	132	137	117	155	912	112	111	114	112	104	07	100	103	115														
24	58,000	L	462	316			243	132	137	117	155	912	112	111	114	112	104	07	100	103	115														
25	58,340	R	370	284	412		331	436	258	255	230	313	292	264	211	144	123	123	205	204	293														
26	62,000	L	377	342			...	663	335	383	410	375	233	271	239	235	230	200	312	319	337														
27	64,340	R	469	366			351	371	348	340	375	107	230	430	333	271	270	203	323	311	332														
28	60,052	R	323	396	233		345	371	292	310	375	107	230	430	333	271	270	203	323	311	332														
29	60,072	R	411	308	436		101	218	108	108	291	218	342	369	318	337	361	190	278	343	407														
30	73,875	R	572	420			...	322	322	322	322	322	322	322	322	322	322	322	322	322	322														
31	73,862	R	1,047	785			477	431	380	348	306	294	332	413	390	404	400	217	363	420	491														
32	72,492	L	637	492	141		404	330	293	214	256	395	129	133	290	302	300	273	362	412	406														
TOTAL			14,554	10,505	5,845	..	8,639	7,031	8,417	8,466	2,436	11,710	9,540	9,702	9,821	9,748	9,225	7,652	8,392	9,604	10,075	11,801													

Punjab.]

Mr. T. A. MILLER BROWNLIE.

Mr. T. A. MILLER BROWNLIE, C.E., M.I.W.E., M.I.M. & C.E., Agricultural Engineer, Punjab.

EXAMINED AT LYALLPUR, JANUARY 15TH, 1918.

Written statement.

VI.—IRRIGATION.

3656. (50) Experience.—For the last ten years I have been engaged on works largely connected with irrigation problems. Two of these years were spent on the Lower Swat Canal, North-West Frontier Province, where I was interested in the losses of water due to absorption and evaporation and, in 1908, these losses between the canal headworks and the outlets to the fields amounted to not less than thirty per cent.

3657. (51) Sewage disposal scheme at Amritsar and the question of lining channels.—Between the years 1909 and 1915, while employed as Municipal Engineer in Amritsar, I constructed a small sewage disposal scheme and irrigated over one thousand acres of land by sewage effluent. The effluent discharge was five cusecs and on the short portion of distributing channel that was lined with brickwork in cement, the absorption losses were practically nil while in the earth or *kachcha* channel these losses amounted to 0·3 cusecs in a wetted area of 32,000 square feet or say over nine cusecs loss per million wetted square feet. These measurements were made between two and three years after the channel was constructed, and on that account may be slightly on the high side, but judging by observations made by officers of the Irrigation Department, the losses in this channel bear a close relationship to losses observed on similar channels of other canals in the Punjab and are in my opinion sufficient to justify the lining of such channels.

(2) On this Amritsar scheme, the rate charged for irrigation amounted to Rs. 12 per acre per crop. If the channel had been lined, an additional area of sixty acres would have been cropped twice in the year, giving an income of Rs. 1,440 while the cost of the lining for a thirty years' life would have amounted to Rs. 4,000, therefore the cost of lining would, in this case, have been paid off in three years and for the remaining 27 years, the additional profits on the scheme would have amounted to Rs. 1,440 per annum less maintenance which would have been practically negligible as the lining is a high quality one, whereas the maintenance of the unlined channel amounts to between one and two hundred rupees per annum, practically the whole of which would be saved in addition to the above.

(3) In small pumping installations for irrigation purposes, the absorption losses in water-courses is not less than ten per cent. on water courses averaging one-and-a-half miles in length, the cost of lining these water-courses would amount to Rs. 3,000 and the average crop value is roughly Rs. 35 per acre. In a one-and-a-half cusec plant, the additional area irrigated would be 25 acres of a potential value of Rs. 875 for one crop and taking one-and-a-half times the area as twice cropped then the crop value is fully Rs. 1,300 which pays off the cost of lining in less than three years.

3658. (52) Utilization of wells for irrigation of cotton in canal areas.—I have had considerable experience of the installation and working of tube wells for the past six years and, in cases where the irrigation canals carry water during the summer months only, I do not consider that the installation of tube wells in order to secure the first and final waterings of American cotton would be a sound financial project.

(2) Any power plant to be run economically should be kept working, and to instal such a plant in order to obtain a water supply for a total period of roughly 2½ months in the year means that the interest on capital, depreciation, for the whole year and the establishment charges for a considerably greater period than 2½ months, if not for the whole year, have to be recovered from these two-and-a-half months' work. Further the cost of power lifting of water is very considerably higher than the cost of irrigation from canals. The appended diagram (Annexure I)* shows the comparative cost per acre per crop (general crops) for irrigation by ordinary wells and by tube wells.

(3) The rate for canal irrigation is that of the Lower Chenab canal and it will be observed that this is approximately Rs. 4-12-0 per acre per crop. The cost of pumped water becomes greater as the lift increases, but it will be observed that the cheapest power scheme is approximately Rs. 7-12-0 per acre per crop on a lift of 24 feet, this is for a plant working constantly or at least for the same periods that canal water would be run.

(4) Irrigation from ordinary wells worked by bullock power on the same lift would cost over Rs. 17 per acre per crop and there is undoubtedly a distinct advantage in power pumping on a large scale *versus* bullock power pumping which shows that on land unirrigated by canals, the *zamindar* is well able to afford the water rates imposed by a power pumping plant and that water can be pumped on a large scale from depths of at least sixty feet at a rate profitable to the *zamindar*, but such schemes can only be successful in areas unirrigated by canals.

(5) On perennial canals, the matter is somewhat different. There are very many falls on the various perennial canals of the Punjab where power has been running to waste for years and these should be utilized for pumping water from tube wells in their neighbourhood. The cost of such pumping would be considerably less than the costs shown on the accompanying diagram but would be in excess of canal rates, and such pumped water could be utilized for the first and final waterings of American cotton when the ordinary canal water is required for other crops.

3659. Effect of pumping on sub-soil water level.—Pumping from the sub-soil has a very local and only slightly retarding effect on the rise of sub-soil water level and I do not consider that it is a remedy for water-logging which appears to be mainly caused by absorption losses from the canals themselves, the remedy being to render these impervious by lining. In new canals and in distributaries and branches of old canals which are closed frequently this presents no difficulty but in main lines where a constant supply has to be maintained the matter involves considerable difficulty and expense.

3660. (64) Suitability of water rates.—Judging from the high rates willingly paid by *zamindars* for pumped water for irrigation purposes, I am of the opinion that the expenses involved in improving the existing and new canal supplies could be satisfactorily met by a slight enhancement of present canal rates. These present rates were fixed at a time when river water was plentiful for the needs of the areas irrigated and canals were designed in a manner not conducive to the saving of water but which owing to their low cost allowed of the fixing of a low water rate. The time has now come for the extension of irrigation by the use of all available river water, and as a considerable extension can be made by canal improvement, I consider that a small enhancement in rates to meet this improvement would be well worth considering.

Punjab.]

Mr. T. A. MILLER BROWNLIE.

[Continued.]

Mr. T. A. MILLER BROWNLIE called and examined.

3661. (*Mr. Ashton.*) I am a Civil Engineer. I qualified in 1901 at Glasgow University and have been engaged on engineering projects ever since. I spent two years on the Lower Swat Canal. I have had no experience of irrigation canals beyond that. I have had pumping experience in Britain and in Amritsar. I put in a sewage disposal scheme at Amritsar, the outlet channel of which discharged about five cusecs and irrigated fully a thousand acres.

3662. I measured the losses due to absorption on the Lower Swat Canal and on several other smaller channels. On the Lower Swat Canal, there was thirty per cent. not less by absorption. There is a certain amount of cotton grown on it and quite a large amount of wheat.

3663. There are over 600 of my tube wells now in use in India. There are probably about 370 in use in the Punjab. I would not advocate the use of tube wells for the first waterings of American cotton on canals running in the summer months only. That would mean that they would operate for only 2½ months a year and it is not sound financially to run any machine only for 2½ months. You have got to consider depreciation, loss of interest on capital and renewals. That would raise the irrigation rates very considerably. It is too expensive a proposition. The zamindars would rather wait a bit and pay the canal rates. The case of perennial canals is rather different. If you could get power from the perennial canals and if water was required for the first watering and the final watering when the ordinary canal water was required for other purposes, then it might be worth while to provide tube wells, provided the power could be used for other purposes. But the plant must be kept working, otherwise it would not pay. It is possible, in certain districts, to run the tubes at a rate that would mean a small addition to the ordinary canal rates but it would be an addition. You certainly could not do it on canal rates. Then again the question of lift comes in. You could make a paying concern of it in areas where the sub-soil water level is within a short distance of the surface. Where the lift is low, it is a question worth considering. It might pay Government to keep down the sub-soil water level but the amount of water you obtain by pumping from the sub-soil is practically negligible. You are not going to keep down the sub-soil water by pumping from the sub-soil, but irrigation by pumping from the sub-soil prevents the application of foreign or canal water to the soil and therefore rise in sub-soil water from that cause is prevented. The actual rise of the sub-soil water is due to absorption from the canal itself and the question of lining comes in again.

3664. As to the question of a central pumping station having a good discharge instead of a number of small ones; I would recommend one central power station operating pumping plant radially situated therefrom. With tube wells, there is an economic discharge relative to the sub-soil water level. On short lifts this is approximately 1½ cusecs per tube well. If you exceed that, pumping becomes uneconomic, but the discharge can be economically increased on greater lifts.

3665. The diagram I have put in shows that pumping is cheaper than working by bullocks, but it is a lot more expensive than canal water. The average rate for the latter is slightly under Rs. 4. Our rate for pumping here is about Rs. 7-12-0 that is on short lifts, i.e., where sub-soil water is ten or twelve feet from ground surface. As a matter of fact, the actual rates are probably considerably under these but these are safe figures, neither too high nor too low. If you get water power from canals, the rate would be still further reduced but it would never come down to canal rates.

3666. We have been putting up tube wells since 1911, and the original estimates allowed for a life of five years but they can probably be used for another five years at least as those which have been in use for seven years now are in excellent order and show no sign of depreciation.

3667. I cannot give any idea of areas where pumping could be introduced with special reference to cotton. There are areas such as Gurdaspur, Sialkot and Amritsar where the water table is fairly high but I do not know if they would be suitable for cotton.

3668. (*Mr. Roberts.*) In the Amritsar and Gurdaspur districts, there are large areas of land at present unirrigated where the sub-soil water is near enough to the surface to make pumping a paying concern. As to American cotton, I may say that there are parts of the Multan district where water could be raised at a minimum cost. Judging by the rates, which the zamindars pay and which go up to Rs. 17 per acre per crop I should say that we can give irrigation at that rate per crop from a depth of sixty feet. Bullock power would work out at the same rate, viz., Rs. 17 from a depth of twenty to thirty feet only.

3669. There is no area in which I would advocate development with tube wells until the possibilities of canal irrigation have been tested. Canal irrigation is at present cheaper and must always remain cheaper than tube wells.

3670. I have been engaged on water supplies at home costing one million sterling. The feeder canals put in there were invariably lined to prevent absorption and loss. The question of putting in a canal of any sort without lining it straight away was never considered. Lining was simply regarded as a business proposition: I had five years' practical experience after qualifying before coming to this country. Undoubtedly lining is always a feasible proposition, merely from the point of view of saving water on the canals as built in this country. When the canals were started, if there was a loss of forty to fifty per cent. it did not matter very much. The area was irrigated and the canal was of course a paying concern. Now-a-days practically all the available water has been taken in the Punjab and it is a question of saving as much as possible. It is undoubtedly possible to recover a large proportion of the water lost by lining.

3671. (*Mr. Henderson.*) A figure of cost of Re. 1 per acre for each watering from tube wells, from depth of ten feet is not a safe figure. It cannot be done. My figure would be at least Re. 1-8.

3672. I have been putting in tube well plants since 1911. As to whether oil engines or steam engines are better, that depends altogether on the part of the country, in which you are putting in the plant. For instance, if you take districts where Bengal coal can be had at Rs. 15 and less a ton, there it would pay to have a steam engine. The nearer you get to the coal supplies, the cheaper it is to run by coal. North of Lahore it pays to put in oil engine in preference to steam. Small oil engines are best for the zamindars as they are more easily worked. As to the feasibility of cotton stalks for fuel, I have not thought the matter over but I believe they could be used in gas producer plant for gas engines in which you can use practically any fuel. You have to consider the size of the plants that you are putting in. A portable plant is more expensive to run than a fixed plant. I have not got a stock plant. I have to make a plan for each individual case as the question of water level in each place has to be considered on its merits. You cannot say that because plant costs a certain sum at Lahore, it is going to cost the same sum thirty miles away. The limits are very wide: we have got water levels here from five to six feet from ground level down to sixty feet.

Sind.]

Mr. F. WRIGHT.

3673. I have experience of vertical spindle centrifugal pumps. It is an excellent type of pump, much better than the ordinary horizontal spindle centrifugal pump. Engines used for purely agricultural purposes do not come under the Inspector of boilers. What frequently happens is that if a boiler is condemned by the boiler inspector, the owner merely sells it to some one out in the district.

3674. Water raised by lift is more economically used than flow water. I noticed that first of all in connexion with bullock power lifts. The *zamindar* divides his fields in much smaller plots, clay lines his water course so as to reduce absorption and is very much more careful about the water. Similarly with tubewells, he recognises that every gallon of water is going to cost him a certain sum and if he loses any it is his own fault. He is therefore much more careful than he is with canal water.

3675. I would not say definitely that a steam engine is better suited to the *zamindar's* work and is more fool proof than an oil engine. There are types of oil engines which are quite as fool proof as steam engines. Speaking generally, steam engines are perhaps more useful than oil engines, because the Indian mechanic has had much longer experience of steam engines than of oil engines. As to the question of steam plant replacing oil plants you have to consider how much more labour will have to be employed, also the situation of the plant in every individual case. On a steam plant you have to employ two men, the engine driver and the fireman, that is the least you can do with; with an oil plant, you can do with one man. Two men are usually employed on steam plants; you could do with one in special cases but I have not seen it done anywhere in India. I do not think that the fact that a steam engine has to be inspected under the Boiler Act, while the oil engine has not to be inspected in any way, puts a bar on the employment of steam engines for agricultural purposes at least not in the Punjab. Steam engines are not inspected outside Municipal limits.

V.—Sind.

Mr. F. WRIGHT, Chief Engineer in Sind.

EXAMINED AT KARACHI, JANUARY 19TH, 1918.

Written statement.

I.—AGRICULTURAL EXPERIENCE.

(a) "Deshi" short staple cotton.

3676. (1) Experience.—My acquaintance with cotton growing is very limited. Up to September 1907, when I left Sind for Roads and Buildings work in the Deccan, I had served in this Province on and off for about 11½ years and in that time I was connected with parts of the country where cotton is but little grown, i.e., in the Karachi Canals, Eastern Nara, Ghar Canals and Fuleli Canals Districts. I served a short time in the Jamrao Canal District but that was on the construction of the canal. I served also for a year (1893) in the Hyderabad Canals District and then saw just a little of cotton but it was not my business to interest myself in this crop more than in any other. Since my return to Sind in January 1917, my duties have not required me to visit cotton growing tracts. I have, however, been to Nawabshah and acquired a sketchy idea, only, of what is done in the Nasrat Canals District.

3677. (2) Varieties.—The Sindhi cotton grown in the Nasrat Canals District is a short staple variety.

3678. (3) Size of holdings.—When a cultivator has to lift water for his crops, he is not likely to cultivate more than one quarter of his irrigated area with cotton. The remainder of this irrigated area he will put under *bajra* and *guar* and this because he must have fodder for his wheel oxen. The area also which a wheel can irrigate is but limited and this fact tends to restrict the part of a lift irrigated holdings which will be under cotton.

(2) Provided water flows in the canals by the end of April or early in May, a Nasrat cultivator, who has flow facilities, may irrigate as much as two-thirds of his land for cotton, the remainder of his irrigated lands will be under *guar* or *bajra*.

(3) If the water is late in coming (i.e., not until the middle of June) a flow lands cultivator will not sow more than half his whole irrigated area with cotton. He takes this precaution because he fears that late sown cotton may be affected by frost. Frost is not uncommon between Christmas and the first week of February.

(4) I do not know what the average size of a Nasrat cultivator's holding is. Holdings vary very greatly in extent.

(5) Cotton sown on an inundation canal which can give water as early as the end of April will yield a first picking by the end of September. Nasrat cultivators are satisfied if they get three pickings even when the cotton is sown as early as April.

3679. (4) Yields and profits.—The cotton yield on the Nasrat depends primarily on the water-supply which unfortunately is not at all dependable on this inundation canal. In recent years, the set of the river at the canal's source has been very unfavourable. On the other hand, when this canal was first opened thirteen years ago, and for some years subsequently, it was particularly well served by the river and gave a good supply while the Indus was still at a comparatively low level. At that time also much of the cotton area was virgin land. No manure was required. Luxurious crops were raised. As time has passed, the land has fallen off much in fertility. Summer rain has become more frequent and with this, grasses have spread widely over the cotton growing tract, a matter which now involves a big expenditure on weeding, if the growing cotton is not to be choked in many places. The Sindhi is the reverse of industrious and will not weed. Nor will he manure. Manure is a difficulty as it is only in the neighbourhood of cattle byres that any is obtainable. Even when the water-supply is good and careful cultivation has been effected, yet in the Nasrat country a cotton crop may be very seriously injured and even wholly ruined by locusts. Here the locusts pest is more in evidence than anywhere else in Sind. It seems these insects breed in the sandhills which adjoin this irrigated tract. Cotton, too, is said to be attacked by white ants and the growing plants are eaten through near the ground and fall over. White ants may injure patches here and there through a cotton field.

Sind.]

Mr. F. WRIGHT.

[Continued.]

(2) Careful cultivation is conducted by but very few. By the expression is meant the giving effect to the following operations:—

- (a) Land watered (sometimes twice) before ploughing.
- (b) Land ploughed.
- (c) Land watered.
- (d) Seed sown.
- (e) Land ploughed once more.
- (f) Weeding attended to as plant grows.

When such work is done on land which has been manured the crop yielded may be as much as ten maunds per acre. But when the whole Nasrat area is considered the average yield does not exceed four maunds per acre.

(3) Now as regards the profits of the Nasrat cotton cultivator. At present the cotton price in Nawabshah (the artificial centre of the cotton tract) is about Rs. 15 per maund. Before the war it was Rs. 8 or Rs. 9 per maund. Consider a pre-war rate of Rs. 9. The average yield per acre being taken at four maunds, the value is Rs. 36. But it is the custom with the Nasrat *zamindar* to give a half share of his produce to his *haris* so that it is Rs. 18 which has to meet the other calls upon the *zamindar* on account of his acre of produce. These other calls are (a) assessment which may be taken at Rs. 3-8-0- per acre, (b) local fund cess which may be eight annas per acre, (c) the cost to the *zamindar* of weeding may be Rs. 2 per acre and (d) the cost of upkeep of horses, wages to *lamdars* (agents) and other helpers may amount to another Rs. 2 per acre, so that the Rs. 18 dwindles to Rs. 10. It seems from this that a *zamindar* in normal times cannot expect to get a return of much more than twice as much per acre as he spends on his land assessment.

(4) I beg to emphasize that my remarks generally are based upon what I gathered from conversation with two or three local land-holders. I have no reason to doubt the trustworthiness of the information given to me.

3680. (5) Rotations and manure.—There are no rotations of crops adopted in the Nasrat cotton area. Land is left fallow for one or two years after a cotton crop. As mentioned already, the only manure used is cowdung, and very little of this is available. It is found that, if the land is ploughed frequently before sowing, the yield of cotton is much improved. This is the course resorted to by the more enterprising land-holders.

3681. (8) Uses of seed and seed selection.—The enterprising Nasrat *zamindar* buys selected cotton seed from reliable merchants such as Messrs. Ralli Brothers. The indifferent *zamindar* buys his seed in the bazaar and that seed is such as is for sale principally as cattle food. It seems desirable that the indifferent *zamindar* should have facilities to purchase selected seed. A Government farm, perhaps, could undertake this duty. It is said that the better seed is obtainable from the hand ginning process as machine ginning is apt to damage the seed, breaking off the pointed tops.

(c) Exotic cotton.

3682. (21) Varieties.—American cotton has been grown experimentally and successfully in the Nasrat tract but in such small quantities that there has been no special demand for this variety. It was suggested to me by a *zamindar* that the growing of this cotton could perhaps be established (a) if Government undertook to supply the seed (b) if each *zamindar* was encouraged to sow one-eighth of his cotton holding with this variety because then if there was a failure of the crop the loss to a man would not be a matter of grave consideration. Then if there was success in the experiment the *zamindar* and the *haris* would acquire confidence in the new variety and they would themselves extend the areas which they would put under this crop.

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3683. (47) Effect of water rates.—I am informed that some Nasrat *zamindars* would be willing to grow American cotton if they were granted a small reduction in their assessment. It was pointed out to me that encouragement of some sort is necessary as the conservative Sindhis—the *haris* in particular—fear to experiment and they believe only when they see. If then they see American cotton growing successfully in all parts of the Nawabshah country, they may take to it. Moreover it will be necessary to have a tolerably large area under American cotton because only when this is available in fair quantities will there be a good market for it at Nawabshah.

3684. (48) Desirability of alteration in water rates.—I am given to understand that the rates current in the Nasrat tract are considered fair. They should not be raised so long as the canal system is an inundation one. When the canal gets a perennial supply, the rates can, with confidence, be enhanced considerably.

VI.—IRRIGATION.

3685. (65) Experience.—I mentioned already that I spent 11½ years of my service in Sind previous to 1907. In that time my work was done almost wholly in the tracts supplied by inundation canals and in tracts where rice is the favourite crop. Previous to 1907, I also spent sixteen months in the tank irrigated part of the Dharwar District. Cotton there is a black soil rain-mixed crop and the Irrigation Engineer sees little of it in the tank areas, where his work lies. I have no experience of canal irrigation assessment work.

3686. (66) Watering of cotton.—Although the Nasrat tract, and indeed most of Sind, is subjected to very hot winds in May and early in June, cotton will not suffer—beyond being retarded a little in growth—provided it is already well grown at that season. Thus it is wise to sow cotton as early as possible and get it well established by June.

(2) Cotton in Sind is generally given about 12,000 cubic feet of water per acre at a time. This corresponds to a delta equal to three inches. If there is no rain, cotton on an inundation canal will require six or seven waterings.

3687. (68) Fluctuations in river supplies and their effects.—As a rule, the Indus in Sind remains at its lowest level throughout the period—November to mid April inclusive. It rises slowly through April and May and more rapidly throughout June and July, reaching its maximum height by the middle of August when it remains high generally until early in September. Then it falls somewhat rapidly.

(2) In Sind, practically every man would grow rice, if he could get the copious water that crop is supposed to require and if there was not restriction to rice growing in certain localities. Rice is popular principally

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[Continued.]

because it is little affected by disease or insect pests and it requires relatively less labour than any of the other crops. Sind is a country of inundation canals and *kharif* crops consequently are mainly grown and when rice is impossible then the millets and cotton are favoured. Cotton, though, is almost unknown in the Larkana, Sukkur and Upper Sind Frontier districts; in Larkana because rice claims attention everywhere and in Sukkur and Upper Sind Frontier because *juar* is popular in the *kharif* season and because there is here more provision left for *rabi*, wheat being very important.

3688. (69) Wells and tube-wells.—There are practically no wells in the Nasrat tract because the sub-soil water is at a considerable depth and, when it is obtained, it is almost invariably brackish. Elsewhere in Sind where wells exist, and that is principally within a few miles of the rivers' margin, they are used chiefly for garden crops when they are used to irrigate.

(2) Tube-wells are not known in Sind. They would not be successful because almost everywhere fine sand is met with in the water bearing sub-soils.

3689. (72) Adequacy of supplies to increase in area under cotton.—I think the area under cotton might be increased appreciably on the Fuleli Canal system in its upper reaches. This canal, gives a fine supply throughout the inundation season and it is the best of the inundation canals in Lower Sind in that a fair irrigating level is available for a longer period than elsewhere and there is plenty of lift lands suitable for cotton in the Hyderabad, Guni and Dero Mohabat Talukas in particular. The canal in its lower reaches feeds lands where the *zamindars* grow rice only, but there is one branch (the Nasirwah) in the southern part of the system, which feeds an area suitable for cotton and where, to my knowledge, good cotton was grown in 1903 and 1904. This Fuleli country is especially suitable for inundation watered cotton from the fact that the winter is not severe and frosts are very infrequent. The reason, I think, why a larger area of cotton is not irrigated in the Fuleli District is that the rice idea is well engrained in the *haris* and the raising of that crop suits their lazy habits better than does the cultivation of cotton which demands more toil and more attention throughout a somewhat longer season of growth. *Zamindars*, I believe, can secure *haris* more readily for rice than for cotton. Many of the Hindu *zamindars* are absentee landlords and a man of that description who has lands in lift Dero Mohabat and flow Badin will devote far the greater part of his attention to securing *haris* for his Badin rice growing property. I believe I am correct in saying that there are several localities in Sind where there is considerable competition amongst *zamindars* to secure *haris* annually. An important factor in Sind is that, at present, the agricultural population is nothing like large enough for the lands which might be cultivated were there more people. Cultivation is conducted in a very slovenly fashion and water is generally used to excess when it can be had easily.

Mr. F. WRIGHT, called and examined.

3690. (Mr. Ashton.) The Sukkur Barrage would affect the whole left bank of the Indus from above Rohri

Year.	Popula- tion.	Total area cultivated.
1801	2,872,000	2,101,000
1901	3,211,000	3,077,000
1911	3,513,000	3,037,000

to below Hyderabad, well into the area now commanded by the Fuleli Canal. The Barrage is absolutely necessary if you want to improve things in Sind. Although the population of the Province has increased cultivation has not kept pace with it, and as regards the cotton cultivated from year to year there certainly has been a steady rise in the area under this crop but none of this area is under long staple cotton, a crop which in Sind must have an early watering.

3691. As regards the Fuleli Canals District of which I have more acquaintance than with other parts of Sind, I think the area under cotton might be increased, especially in the upper reaches of the canal. This canal is one which can flow all the year through though its cold weather level is much below the general ground level of the country. But pumps driven by steam engines could be fitted up along the borders of the canal and with these water could be made available for cotton in March and April. It is my opinion that if Government wish to develop American cotton in Sind before the coming of the big perennial canal schemes there is no place more favourable than is this Fuleli region. Here the winter frosts occur very rarely indeed and that is important when cotton is flowering late in the year. This matter of pumping water from canals has not been gone into by the Irrigation Department, but it is not novel since *zamindars* are more and more taking to steam engines and pumps when they want to lift water for garden lands, especially as these lands generally adjoin the old deep canals which can be depended on to hold water throughout the year. I have observed that many such pumps have been installed on the Fuleli—a dozen perhaps—since I knew the canal ten years ago. I do not think we can expect a much larger area to be brought under irrigation by bullock lift than that which is irrigated at present. *Zamindars* might be induced to take to cotton cultivation if the assessment, already really very light, was reduced somewhat, but it is not the policy of Government to reduce assessments except for very good reasons, and particularly now with these perennial canal schemes which are likely to mature as soon as normal times return. It is difficult to compare lift and flow rates. As a general rule lands irrigated by lift are more lightly assessed than are lands irrigated by flow. The flow rates vary with the locality and water facilities. The rate for rice is probably the highest and it is about Rs. 4 per acre.

3692. A barrage constructed across the Indus at Sukkur would help things very much on the Jamrao Canal. This canal is the only truly perennial canal in Sind. It has been open since 1900 and was never closed until 1917 when extensive silt clearance had to be done in the mouth portion. But few of the minors of this canal can be brought to work to the discharge they were designed to carry. This is due largely to the supply of the Nara having many of the uncertain attributes of the parent river. Low river gives low Nara and often insufficient water for the Jamrao in the *rabi* season.

3693. There is no reason why cotton should not grow well on the right bank of the Indus except that that country now is almost wholly a rice growing country. North of Sukkur, there is plenty of suitable cotton land. South of Sukkur, that is to say the Larkana Collectorate, the *kharif* cultivation now is rice almost entirely. Below the Larkana Collectorate comes a hilly strip extending from Sehwan to south of Kotri, when the deltaic country adjoining Karachi is reached, and this again is wholly a rice country.

3694. I would not say that rice land is fitted for nothing but rice. I know of places adjoining the Jamrao Canal where cotton is now grown on land that formerly was used solely for rice. It is grown here because the *zamindars* see from the adjoining Jamrao area, where rice is not permitted, how profitable cotton is and for these reasons they have voluntarily abandoned rice.

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[Continued.]

3695. Taking Sind as a whole, the cultivators have a most decided preference for the *kharij* season crops. They prefer rice to any other crop. If they had their way, many of them would grow nothing but rice. Restrictions upon rice cultivation have to be imposed in many localities and these restrictions are very necessary especially because the amount of water taken for rice cultivation in Sind is extremely heavy. Restrictions are enforced principally when new canals are made. To curtail the present area annually cropped with rice so as to induce the people to cultivate other crops such as cotton would probably require special legislation.

3696. The Sukkur Barrage project is at present in a state of flux. The trouble has been that responsible officers have disagreed fundamentally as to the main principles of the scheme. Now special officers are about to be appointed to examine conditions in the tracts to be irrigated and to see what lands hitherto supposed to be unculturable are really culturable and *vice versa*. It is well recognized that there is much land suitable for extensive cotton cultivation on the left bank of the river particularly, but even when this land becomes perennially irrigated there is no guarantee that cotton will be favoured specially; people will grow what pays them best. Cotton is a delicate crop and has its diseases and parasites, and locusts damage it some times very extensively. The people know that, and fight shy of it, even of their own indigenous Sindhi cotton.

3697. (Mr. Henderson.) There are several varieties of rice but in general this crop can be classed as of two kinds, that which is raised after transplantation and that which is sown broadcast, a commoner kind. In Lower Sind, the people prefer the broad cast sown red rice because it is less troublesome. The best rice in Sind is grown in the Larkana District and it is quite certain that no *zamindar* there would substitute the cultivation of cotton for rice. This Larkana rice is highly prized. Good rice land and bad rice land should be distinguished, as they rightly are, in all settlement revisions. It would be possible to substitute cotton for rice in tracts where the water supply was not as abundant as the rice grower thinks requisite but it would not be practicable to reduce the water supply in the red rice country with the view thereby of inducing the cultivators to take to cotton instead of rice; the fact is that, in the red rice country, the number of *haris* is very limited and those that are found will not grow cotton so long as rice can be grown.

3698. In Lower Sind the *zamindars* are very largely in the hands of the *haris* and they compete amongst themselves to secure the services of these *haris*; the consequence of this is that *haris* frequently break their contracts with a *zamindar* leaving him in favour of another *zamindar* who offers better terms or whose lands are more to the liking of the *haris*. *Zamindars* thus have often to spend time running after absconding *haris* and recovering advances made to them. This may mean that cultivation suffers in the meanwhile. Some *zamindars* have friends amongst the subordinate officials and these men can give much assistance in finding absconding *haris* and inducing them to work. In Lower Sind, very few of the Hindu *zamindars* live on their land. They prefer to live at Hyderabad which is the home of a large number of Amil *zamindars*, a class of Hindu, which in recent years, in particular, has taken to agricultural pursuits.

3699. In Upper Sind the land is much more intensively cultivated than in Lower Sind and this is so particularly near the river. In this riverside country, the people have made a fairly large number of wells and at such places one sees numerous Hindu cultivators—a class one practically never sees in the delta *talukas*. But cotton is not grown here and that probably is principally because of the conservatism of the people. In Sind, the evils of long fallows and of bad cultivation and of waste of water are partly due to the sparsity of population, partly to the lazy habits of the people and partly to the safety which attaches to the growing of rice.

3700. In the old rice canals in Upper Sind, a policy of reducing the size of outlets at the heads of the *zamindars'* water-courses has been in force for some time. This meets with much opposition as the *zamindar* has the tradition that unless he has an abundance of water this rice crop will suffer. We aim at giving a man one ounce for thirty acres of cropped rice land. This is very liberal. The *kharij* duty on the rice irrigating flow canals in Sind compares very unfavourably with the duty elsewhere in India. When, on the other hand, a man has to lift the water for his crop the duty is very good; such a cultivator lifts only what is really necessary for his crop. The flow irrigator wastes water most excessively. In Sind, the *rabi* duty is very low, comparatively. This may be due to the *kharij* tradition of "take the water while you can" manifesting itself in the winter season. It must be remembered that until within recent years practically no *rabi* irrigating was done in Sind. The low *rabi* duty may also be due locally to the fact that the lands irrigated are *kalar* impregnated and for these ample watering is needed. Cultivators will advance this *kalar* bug bear when asked why they use water extravagantly. There is *kalar* and *kalar*. Some land is almost hopeless as a crop producer because of *kalar*, but such land is exceptional; other land, though *kalar* impregnated, produces good crops quite regularly. *Kalar* is prevalent almost everywhere.

3701. (Mr. Roberts.) The cultivators sowed cotton largely in the new Nasrat Canal area when the canal was first opened. Then this canal's head was very favourably situated for a supply from the river. The canal then flowed as early as April and *zamindars* who took advantage of the early water, on lands which were virgin lands in the neighbourhood of Nawabshah, are reported to have made their fortunes in a few years. River changes at the mouth of this Nasrat Canal have now affected its supply very seriously, so much so that it can only be classed at present as a poor canal system. The canal has its source from an arm of the river which is in Khairpur State and we have not free access to the State to make temporary or subsidiary mouths when such suddenly become necessary owing to vagaries of the Indus. The cotton cultivation on the canal has suffered in consequence.

3702. The principal difficulty in getting American cotton established in Sind is that for success it must be sown early and the water is not available in April. If we had perfectly reliable perennial canals (the Jamrao is hardly such) there would be no feeling of doubt with the *zamindars* as to the permanence of water supply and American cotton would be planted in April with complete confidence. With perennial canals, it is expected that the extension of *rabi* cultivation in Sind will be most remarkable once the *zamindars* are satisfied that wheat will pay them well. There may be overlapping between the *kharij* and the *rabi* seasons but I do not think this will be extensive once men learn to sow a great part of the *kharij* two months or six weeks earlier than is customary now with the inundation canals. All *rabi* operations ought to be over by the beginning of April annually provided the winter months have not been sickly. At the present moment (middle January) fever is so bad that rice is still standing uncut in many places.

3703. In many parts of Sind—on the Nasrat and Fulci systems for instance—there has been a great increase in the way grasses and weeds have been growing. This is attributable to the very low intensity of cultivation. Had the cultivation been more intense the seeds of the weeds would have been cared for and the grasses also would have been eradicated.

3704. From the irrigation point of view I know of no objection to an increase in the cropping of land to 100 or even 120 per cent. The principal hindrance to such intense cultivation is that the land would want

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rest or else manure. The issuing of water for irrigation in Sind will never be an obstacle, once the proposed perennial canals are in being but of course water-logging must be carefully guarded against.

3705. The figures of yield given in my written evidence are those which I obtained after discussing such matters with several reliable enterprising *zamindars*. I have no personal knowledge one way or the other of the accuracy of those figures. Since I obtained them, six weeks ago, the value of cotton has risen considerably, also the yield per acre this season has seriously decreased owing to bitter frosts at the end of December.

3706. (President.) It is very difficult to restrict the cultivation of rice when once a man is growing it. We generally make restrictions about rice cultivation when we make new canals in a country where rice hitherto has been non-existent. In this matter we work with the Revenue Department, that department having decided first of all what kinds of crops are most suitable for the general welfare of the community. Of course, a new canal made in a country where rice is the crop will also be designed, probably, to carry sufficient water for rice cultivation. Then this rice restriction will not be contemplated. If a *zamindar* grows rice in a tract where its cultivation is prohibited, he is liable for punishment but I do not think that he is adequately punished by merely being required to pay a double assessment.

3707. (Mr. Wadia.) The *zamindars* on the Nasrat all grow Sindhi cotton. Some have tried American cotton and one *zamindar* told me that he had raised a small quantity of it recently but could get no additional price for it as there was no demand. He also told me that he was confident that he could grow much American cotton successfully and would do so if he was assured of a market. The little American cotton he had grown he had to lump it with his Sindhi. He said the difficulty about American cotton growing was that he did not at present get water early enough in the season. To induce *zamindars* to take to American cotton it was suggested that the assessment be reduced until the commercial value of this variety had come to be recognized.

3708. (Mr. Hodgkinson.) The estimated cost of the Sukkur Barrage scheme is about nine millions sterling (two millions barrage and seven millions canals). There have been several estimates already but these vary considerably as the views of officers as to requirements vary.

3709. As regards the outturn on the capital outlay, I should say that unless the assessments are enhanced fairly severely in some instances it would be a struggle for the project to pay four per cent. In order that a work may be classed as productive, it must give a return of more than four per cent. If the assessments were similar to the Punjab assessments, the return would be distinctly more favourable. The idea of perennial canals originating at Sukkur is a very old one, for in 1855 Colonel Fife first suggested the Rohri Canal. Then came Mr. Joyner's investigations in 1891, followed by Dr. Summers' work which began in 1904. Dr. Summers at first devoted his attention to a project for a purely inundation Left Bank Canal, similar to the Fuleli in many respects but greater than it. This inundation canal was to replace the many similar canals which at present take off from the Indus between Rohri and the Fuleli (Hyderabad). Such a great left bank canal was to command an immense tract of approximately 4,800 square miles. Then came the question of making such a canal secure. It was in order to ensure that the canal should be free from the risk of silting up and in order to make things better all round, steadiness of supply at all times for instance, that the barrage was proposed.

3710. (Mr. Ashton.) I have seen the duty on rice as low as ten. I do not suppose that it would be more than 25 on an average. The duty of *juar* and *bajri* would be sixty perhaps. Rice is given an immense quantity of water. It takes at least three times as much water as cotton although the assessment is similar, Rs. 4 per acre. We are going to try to put up the rice rate to Rs. 7 or Rs. 8 in some distinctly new rice tracts and see how the people take it. In my opinion, the assessment on rice ought to be doubled.

3711. (Mr. Wadia.) As the rules are at present, a project must pay four per cent at least in order that it may be sanctioned by the Secretary of State as productive. The Rohri-Hyderabad canal would pay nine or ten per cent if we could work the system without a barrage and had enhanced assessments.

3712. In my opinion, the barrage is necessary. Some authorities have recommended the canals only without the barrage. I used to favour that scheme at one time but I have been converted.

Mr. R. T. HARRISON, Superintending Engineer, Left Bank, Karachi.

EXAMINED AT KARACHI, JANUARY 19TH, 1918.

Written statement.

VI.—IRRIGATION.

3713. (65) Experience.—I have served for fourteen years in Sind where the work is practically wholly irrigational. I have no experience of canal irrigation assessment work.

3714. (66) Watering of cotton.—Given an assured water-supply, as on the perennial system in this Division, of which the Jamrao Districts are the main examples, cotton is sown from the middle of March to the middle of June. In the inundation canal districts which are solely dependent on the rise of the river, sowings are much later and the *zamindar* will sow cotton up to the end of July though this is the extreme limit of time, for he stands the grave risk of frost before the crop matures. The cultivation is the same in all cases. The land is flooded heavily, then ploughed and the seed sown. A month or so later, the first watering is given to the young crop and those waterings to the number of eight or more are continued up to the end of September on the inundation canals (when the water-supply fails with the fall of the river) and to the end of December and even later on the perennial systems. The volume of water required per acre varies with the soil and atmospheric conditions but may be taken generally as 10,000 cubic feet or say three inches of water over the acre at each watering.

3715. (67) Cotton versus wheat.—The preference throughout Sind is for *kharij* to *rabi* and consequently if the comparison be limited to cotton and wheat, the former as a *kharij* crop will be preferred to wheat—a *rabi* crop. Given *carte blanche*, however, in his choice, the Sindhi prefers rice beyond all else and so rooted is this preference that to economise the water-supply, of which this crop takes such toll, the cultivation of rice is now restricted throughout Sind. This has led to an increase in the cultivation of cotton and where, as on the perennial systems, the water-supply is assured, cotton is the main crop. Given equal facilities in the supply of water, the *zamindar* would take as kindly to cotton on the inundation canals also. He makes

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the attempt very often but has as often to abandon the cultivation in favour of some such quick growing crop as *juar* or *bajra* because the river fails him. The preference for cotton is mainly that it is *kharij* crop and pays better generally than wheat.

3716. (68) Fluctuations in river supplies and their effects.—In a good year, the Indus rises gradually from the middle of April, attains its maximum in July and August and falls gradually from the beginning of September. The inundation period, as it is termed, is from the 15th June to 15th September and the canals are generally all opened by the end of the first week in June. Given these good conditions, and excepting rice, the preference is for cotton.

3717. (69) Wells and tube-wells.—There is very little well irrigation throughout the division. Where the cultivator has taken kindly to this form of assistance, as in the Nasrat Canals District, no Government aid is needed for its extension. He will take the initiative himself as he has taken it already. Where the initiative is lacking as in the other districts, I can see no hope of arousing it.

(2) I have no experience of tube-wells.

3718. (70) Suitability of existing water rates.—There are no water-rates as such charged throughout Sind. The assessment includes the water rate. On the perennial systems, the cotton assessment could stand an increase without detriment to the area grown and should be increased because of the greater quantity of water used in comparison with other dry crops, the ratio being 2 to 1. But on the inundation canals, though the same reason holds, the rate may remain as it is in the present special circumstances as an incentive to cultivate cotton. It stands as an anomaly that on the Jamrao, where the water supply is assured, the rate should be no higher than Rs. 4 per acre as compared with Rs. 3-2-0 on the inundation canals: and, again, that on the inundation canals, the same assessment is charged for cotton as for other dry crops which consume only half the amount of water.

3719. (71) Cropping and causes affecting it.—This is a difficult question to answer with any accuracy. Taking the division as a whole and the *kharij* figures for a good year such as 1914-15, the cotton area was 324,000 acres and the fodder crops such as *juar* and *bajra* 475,000; whereas in a rather poor year such as 1912-13 the figures were, cotton 279,000 acres and *bajra* and *juar* 560,000 acres. Therefore, though the figures are not very conclusive, it shows to some extent the effect of a good and bad water supply.

(2) Rotation of crops is not practised in Sind. Water is provided for a third of each *zamindar's* holding and, as the holdings are generally so large, the *zamindar* can easily subsist on the proceeds from this proportion of his possessions and, at the same time, it gives the soil necessary rest without the need for the rotation of the crops.

3720. (72) Adequacy of supplies to increase in area under cotton.—The water supply available would suffice for a marked increase in the area under cotton were it assured. It is only necessary to look at the Jamrao where though the soil is at the best no better than elsewhere and generally inferior, cotton leads the next crop, *bajra*, in the ratio of 3 or 4 to 1.

3721. (73) *Deshi* versus American cotton.—*Deshi* cotton is unquestionably preferred to American. It may not give the yield perhaps of the American variety at its best but, to the not industrious Sindhi, it appeals on the ground of its much easier cultivation. It possesses also the conspicuous and inherent advantages of being far less liable to the ravages of the bollworm and resists frost to a much greater extent. Further American cotton requires an early and assured water-supply which therefore counts it out for cultivation on inundation canals.

Mr. R. T. HARRISON called and examined.

3722. (Mr. Ashton.) Long staple cotton wants an assured supply of water early in the *kharij* and also late in the *kharij* and, in order to ensure this in Sind, there is no alternative to the Sukkur Barrage. That would affect the whole tract right down to the Fuldi Canal. It would also affect the Jamrao and the Eastern Nara Districts. Nothing could be done to increase cotton cultivation in the lower portion of the Fuldi District. Three Barrages are proposed eventually for Sind; one at Nithankot, one at Rohri (the Sukkur Barrage), and one at Jherruck. I do not see that anything can be done unless you have the Sukkur Barrage.

3723. The Karachi Canals District is not now in my charge but I have been Executive Engineer there; the land is very poor and full of *kalar*. I doubt if cotton would do as well there as in the northern parts of Sind but still you could grow cotton.

3724. Pending the construction of the barrage, I do not think that the area of cotton could be increased by pump or well-irrigation. Where the *zamindars* have taken kindly to well-irrigation and see the advantages of it as in the Nawabshah Collectorate, especially in the Kandiaro Taluka, they do not need any incentive; but elsewhere, generally speaking they do not take kindly to well-irrigation. In the lower portions of Sind, the land is often full of *kalar* and the water is often brackish and so it is not much use sinking wells.

3725. We count our inundation season from the middle of June to the middle of September. The maximum rate for cotton under flow irrigation is Rs. 4 on the Jamrao and Rs. 3-2 on the other inundation canals. There is no rice grown on the Jamrao. Rs. 3-8 or Rs. 4 is the maximum rate on the other canals. Rice takes very much more water than cotton and I certainly think that it ought to be charged a very much higher rate. If we are ever to economise water, we must raise the rate on rice. But on the other hand, it must be remembered that in the case of the Larkana district, rice of very good quality has been grown for ages and in the Karachi Canals District, the soil is so poor that it will probably grow nothing but a very poor quality of rice. It is red rice of the poorest quality. It is only by putting a punitive rate on rice that the cultivation of rice crop can be kept down. If the barrage is constructed, I consider that all crops ought to pay a higher rate than at present. As I have stated in my written evidence, I consider it an anomaly that the rate for cotton on the Jamrao should be Rs. 4 with an assured supply of water, whereas on the inundation canals it is Rs. 3-2. The rate includes the land revenue. We have no water rate as a separate rate. Of course, if we get the barrage, the rates could go up to the Punjab rates i.e., Rs. 8 for cotton but not at once. We should have to work them up gradually. There is no reason whatever why the rates should not go up. Every body agrees that Sind is very lightly assessed at the present time. The *zamindars* are now getting about Rs. 18 per maund of *phutlies* (unginned cotton). Before the war a rate of Rs. 6 used to pay them.

3726. In Sind the supply of labour is a very difficult problem. It is a very great trouble on the Jamrao, where the *zamindars* depend on Thari and Marwari labour to a very great extent. This year there was so much fever about that the harvesting was very backward everywhere. If the barrage came, the question of increasing the number of cultivators would have to be considered. It has been tried on the Jamrao by bringing in Punjabis. If we could get the Punjabi, he is a very fine man indeed. The land which could be colonized

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is scattered in patches. That would be the difficulty, of course; you could not expect the Punjabi or any other labourer to come unless you made him a *zamindar*. I don't know how you would get him to come as a *hari* pure and simple. I do not see what you could do to overcome this difficulty.

3727. It is absolutely necessary to have the barrage, if there is to be any really considerable increase in the area under cotton.

3728. (Mr. Henderson.) I have not personally seen any American cotton grown. Last year there was no American cotton on the Jamrao as the canal was being cleared but the crop has not taken on. Even if a premium of Rs. 4 or Rs. 5 were given for American cotton, I doubt if it would be sufficiently attractive. I do not believe that the Sindhi cultivator will abandon his short staple *deshi* cotton for any thing else. His preference for it is deeply rooted. I am only looking at the question from the length of time during which experiments have been tried with American cotton. They have been going on for six or seven years. If the *zamindar* could get the intrinsic value of his cotton, which I say should be at least Rs. 6 per maund over *deshi*, it might induce him to grow American cotton. Some of the conditions in Sind are the same as in the Punjab but there you have got a much bigger population and a very much more industrious one. I think you could convince a man who *wants* to grow American cotton, very easily but I do not think you will be able to convince the Sindhi. The *zamindars* are to a great extent in the hands of their *haris*. The *hari* will not touch American cotton unless he can be assured of getting a better price for it than for Sindhi cotton. If you want to expand cotton, I see no other way but to have the barrage. Buyers will not give a better price for American cotton unless they can get a decent amount of it. I think it has been agriculturally proved that you can grow American cotton in Sind. I think that it is now a question purely of inclination. If a proper price can be got for it, there is nothing to prevent its being grown. You must give it an early and assured supply of water and the full number of waterings whatever they are, ten or twelve. American cotton will not grow in the delta, as the soil is so very bad and too near the sea. South of Badin in the Fulchi District the soil is particularly bad. It is water logged and all the wells are brackish.

3729. Cotton on the Mithrao is increasing very appreciably because there we have restricted the cultivation of rice. We have restricted the cultivation of rice throughout Sind. In projects for remodelling or improving existing canals, we make an allowance for the area of rice which is in existence but we permit no increase on that area and is entirely new projects, as in the case of the Jamrao and Hiralwahi, we make no allowance at all for rice.

3730. During the last three years there has only been one closure of the Jamrao. That closure was last year. The previous closure, speaking roughly, was ten years ago. The water supply of the Jamrao is assured but limited. We can guarantee some water but not all the water that we want. That is where the barrage will help us. We are wholly dependent on the vagaries of the river at Rohri where the supply channel takes off. In 1908, there was heavy erosion above the supply channel head at Rohri and the channel silted up for several miles down from its mouth so we had to close and clear it. The designed *Harif* discharge of the Jamrao is 3,200 cusecs and the *rabi* 1,800 cusecs. It has been shut on occasions for a month or more for the purpose of inspecting the regulators and repairing all masonry works. A three months closure shakes the confidence of the *zamindar* even though he appreciates the benefit of clearance in improving the supply.

3731. Cotton has to be watered up to the end of October and sometimes the waterings are continued up to the end of January. That affects the *rabi* duty and even the *rabi* area. The rate for this late watered cotton is one rupee an acre higher than the normal *Harif* rate. The outlet designed for the Jamrao is one cusec for 300 acres gross holding or for 100 acres permissible areas annually cultivated. On inundation canals, the figures are 180 and 60 for dry crops. When designing an outlet we estimate on the following lines. If a man owns 300 acres say on an old canal he is provided (on the principle of two years' fallow and one year cultivated) with water for one-third his area, i.e., 100 acres. With a duty of sixty acres per cusec, this entitles him to $1\frac{2}{3}$ cusecs (or say two cusecs) and he can do as much cultivation as he likes with this quantity of water. There is similarly no restriction on the Jamrao. On the Jamrao, we guarantee water for one-third of the area per annum, apportioned as to one-fifth in *Harif* and one-eighth in *rabi*. A man can cultivate more than that if he likes, but he does so at his own risk. He is assessed on all he cultivates. We do not consider any complaints in regard to areas cultivated above the 33 per cent maximum. We keep to the same figures of duty but I think we should increase them, in new projects. Generally speaking, on the Jamrao, the *zamindar* cultivates more than one-fifth his area in *Harif*. An increase in the duty is the only way of making them thrifty in utilising their supply of water.

3732. (Mr. Roberts.) On the Jamrao canal, cotton is sown from the middle of March to the middle of June. There would be no difficulty if the supply of water were available, in the early sowing of American cotton, as the cultivators are already used to early sowing. In a year like the present, when the Jamrao was closed from 15th March to the 25th of May, it was impossible to grow any American cotton. It can not be guaranteed definitely that there will be no more closures of the Jamrao during the next ten years. As to whether it is impossible to grow long staple cotton under such conditions, as it requires to be sown in March, I think, the *zamindar* would take the risk if he could be made to see the advantage of sowing American cotton. He has to take risks now on the inundation canals in the case of *deshi* cotton. On the inundation canals, it is often the case that when he sows the *deshi* cotton and the river fails him, he does not bother further about cotton but grows *bajra*. He would take the chance on the Jamrao, if he could be persuaded that it is to his advantage to grow American cotton but I do not think he can be persuaded. For the introduction of American cotton, it is essential that the yield should be practically equal to that of Sindhi cotton. If that can be assured and if the cultivator can also be assured that the market price will be better for American cotton than for Sindhi cotton, then he will sow it. American cotton is not so hardy because it is more liable to frost and also more liable to boll worm. If the cotton were sown in March and April, I think very little of it would remain so late as to be affected by frost. Frost is a question of late sowing. This is only what I have heard as I have no personal experience of American cotton. I have always understood that it is more susceptible to boll worm than *deshi*. The essential point is to convince the cultivator that the yield of American cotton is as good as that of Sindhi cotton and that the market price is better. I do not think that he would bother about the boll worm or the frost then. As I know the cultivator, he sticks to his preferences very closely and is very hard to convince. Until we get an assured supply of water, we can not expect any big increase in long staple cotton in Sind. You must assure American cotton an early supply and a continuous supply. That counts it out on inundation canals, which do not open until the beginning of June. If you want to give an incentive to the

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cultivation of American cotton, I do not think it is advisable to raise the rate yet. But when an assured supply of water is given, then I think we have a claim and have a right to charge a higher rate.

3733. The cultivator does not take kindly to rotation of crops. The only way to educate him up to this is to provide him with less water. The present system is two years fallow and one year cultivated; the reason is to revive the land and also because our canals can not supply more water. Putting these two reasons together, the system works out very well. The Sindhi practically never rotates his crops. He has never taken kindly to the cultivation of *berseem*. The holdings are very big in Sind. I should like to see a higher percentage of cropping tried. The present system does not enable the land to be kept clean. If a *zamindar* has a holding of 3,000 acres, of which he cultivates 1,000 acres, he gets as much as he wants to live on. The labour question is one of great difficulty, and he has to obtain a sufficient amount of labour to cultivate that 1,000 acres. He could cultivate the whole of his holding if he could get the labour and the water, but that would mean increasing the size of the present canals. If labour could be imported, it would be excellent. If the labourers came as *haris* pure and simple, the difficulty would be much lessened. There are no other reasons for keeping the intensity of cropping so low. From an economic point of view, it is a bad thing that there should be these enormous holdings in Sind. A *zamindar* with 10,000 acres, which is not very uncommon, does not attempt to cultivate it all. What you have to fear is waterlogging as has happened in the Punjab. We do not notice it particularly on the Jamrao but even there the fear exists.

3734. (Mr. Henderson.) It would not be possible to open the inundation canals any earlier. Generally speaking, the river never rises sufficiently high to open any of these canals, before the beginning of June, but we work by gauges and if by any chance the river has risen sufficiently high, the canals open on the 15th or 20th May. The reason the cultivators have not taken to cotton in the Shikarpur Canals and Begari Districts is that the *haris* will not grow it. They will not take the trouble. American cotton will grow, generally speaking, all over Sind, except in the Delta portion.

Mr. C. O. LOWSLEY, Executive Engineer, Fuleli Canals District, Sind.

EXAMINED AT KARACHI, JANUARY 21st, 1918.

Written statement.

VI.—IRRIGATION.

3735. (65) Experience.—I have thirteen years' experience of irrigation under canals. I have no experience of canal irrigation assessment work.

3736. (66) Watering of cotton.—In the Fuleli Canals District, cotton is not watered before the beginning of June as the river level is not high enough on the average to water before this date. Eight to ten waterings are given of two inches to four inches depth each. The first watering is the heaviest and the average can be taken at five inches, which gives a volume of 11,000 cubic feet per acre.

3737. (67) Cotton *versus* wheat.—Cultivators prefer cotton to wheat as cotton is a *kharij* crop and the cultivator is only keen on *rabi* cultivation when he cannot get water for *kharij*. Cotton in past years, with few exceptions, has been the better paying crop.

3738. (68) Fluctuations in river supplies and their effects.—The supply in the river increases gradually in the spring and the fall is usually sudden in the autumn.

(2) The cultivator's preference is for rice wherever he gets an assured flow supply. The failure of the river to rise early does not affect the rice crop so much as the transplantation period is elastic and if a sudden fall is anticipated, the crop can be given a very heavy watering to bring it to maturity. Cotton, if not sown early, gives less outturn owing to its being affected by cold weather late in the season.

3739. (69) Wells and tube-wells.—With the exception of a few wells for garden purposes and the rearing of rice seedlings, no wells exist for cultivation in the districts in which I have served. I do not think the Sindhi cultivator will ever take to well cultivation.

(2) I have no experience of tube-wells.

3740. (70) Suitability of existing water rates.—I am of opinion that the existing rates for cotton are low considering the quantity of water used, but, at the same time, I do not advocate raising the rates so long as the supply is not assured. The canals of which I have experience are solely dependent on the state of the river and as early watering is necessary for cotton cultivation and the price of cotton fluctuates considerably, I think any increase in rates would result in a decrease in the area cultivated. That the price of cotton affects the area considerably is shown by the following figures for the Fuleli Canal:—

The average area under cotton is 24,000 acres. The following are the figures for the past four years—

1913-14	23,002
1914-15	21,640
1915-16	11,590
1916-17	16,640

This clearly shows that the slump in the price of cotton due to the war resulted in a decrease of fifty per cent. in the area cultivated and that, on the price improving, the area under cultivation is again on the increase.

3741. (71) Cropping and causes affecting it.—In the districts of which I have experience, the area of crops grown varies so much that no useful figures can be given. The areas are affected by the water-supply chiefly in connection with cotton and *Lajra*. With a late rising river, land which was intended for cotton, is cultivated with *bajra*.

3742. (72) Adequacy of supplies to increase in area under cotton.—Sufficient water is available for an increase in the cotton area in an average year, but the difficulty is to get an early supply. A larger area is not cultivated for several reasons (a) The fluctuating price; (b) the risk attending late sowings owing to the failure of the river to rise early in June and hence a poor crop affected by the cold late in season; (c) expenditure on weeding and difficulty in obtaining labour to carry out this work; (d) damage by insects.

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3743. (73) *Deshi versus American cotton*.—Cultivators prefer *deshi* (short staple) to American or any other cotton for the following reasons. (a) It gives a better outturn for the minimum amount of labour in cultivation; (b) It is harder and less liable to be damaged by cold at the end of the season; (c) It is less affected by boll worm; (d) The cultivators understand it and it requires the least amount of care.

3744. (74) *Effect of canal regulations*.—Canal regulations create no difficulties with regard to the cultivation of American cotton.

Mr. C. O. LOWSLEY called and examined.

3745. (Mr. Ashton.) I am in charge of the Fuleli Canals district. Along the main canals and main branches watering is started by lift before flow irrigation becomes possible. I do not think that much could be done to make lift irrigation more popular and to extend it. There is very little possibility with pumps. The cost of pumping has not been worked out. The last watering is given by lift. I think it would be desirable to give *lakari* for the purpose of encouraging lift irrigation.

3746. A portion of the tract commanded by the Fuleli Canal is included in the Rohri Hyderabad Canal Project. That is the only large project in connexion with the Fuleli. The area included in the Rohri Hyderabad scheme is roughly about a sixth of the whole commanded by the Fuleli Canal (I understand the original area proposed has been much reduced by the officers on special duty). It is the northern part. The Rohri Hyderabad scheme is the only way of improving the supply. The only way to get an assured water supply is to have the Barrage Scheme. The barrage is absolutely necessary.

3747. (Mr. Hendrean.) The Fuleli is one of the largest inundation canals in India. The cultivation under it is increasing. The area under cotton has been falling for the last two or three years. I think the average area under cotton is about 25,000 acres; it went down to 11,000 acres in 1915-16 but went up again last year to 16,000. Cotton is chiefly cultivated in the northern portion and in the extreme east where the Fuleli Canals district is bounded by the Jamrao district. I do not think the practice of the zamindars on the Jamrao would affect the question of cotton cultivation on the Fuleli. It is only in the recent years that cotton cultivation has become of importance on the Fuleli. It was started about twenty years ago and the figures are:—

1897-98	16,000
1898-99	14,000
1899-00	15,000
1900-01	11,000
1901-02	13,000
1902-03	18,000
1903-04	21,000
1904-05	23,000
1905-06	27,000
1906-07	25,000 1st 10 years.
1907-08	23,000
1908-09	22,000
1909-10	18,000
1910-11	25,000
1911-12	27,000
1912-13	17,000
1913-14	24,000
1914-15	23,000
1915-16	12,000
1916-17	16,000

Against that, rice has been on the increase. Cotton is grown on the higher ground where they cannot get sufficient water for rice. There is no chance of cotton extending to the south even if the water supply diminishes. The extreme south of the district is waterlogged. It is very low ground subject to floods. The floods are due to excess water in the Fuleli as well as to rain. The rainfall is heavier in this tract than it is elsewhere. The rainfall at Badin averages fifteen inches per year against eight or nine inches in Hyderabad in the northern part of the district. Badin being so low takes up practically all the rainfall of the district. I think the sub-soil water is so high that it will take many years before it is possible for the land to be made fit for cotton. The land is also *kalar* land which is, I suppose, due to the waterlogging. The extreme end of the district is only six feet above sea level. Badin itself is about 200 feet above sea-level.

3748. On the Eastern Nara, I have seen land which used to be rice land cultivated with cotton. I have seen the cultivation changed twice in six years. The land was converted from rice to cotton and from cotton to rice. In my opinion, it was converted into cotton because cotton was then the more paying crop and it was converted back to rice because of the slump in the price of cotton. Also I believe that the land was very good flow land and not very low land and hence there was no fear of flooding and the water was under proper control.

3749. We already have a Fuleli escape but it has not sufficient capacity at present to take off the surplus water and the Fuleli head is regulated by vertical needles which take at least four days to close. The result is that when there is rain in Badin, we always get surplus water there before we can cut off the supply at the head. That is the cause of many breaches and, combined with the rainfall, results in the flooding of the Badin Taluka. Cotton can not be cultivated in the area which is not waterlogged in this tract as the *kalar* soil is too bad for it. Cotton has been grown in Badin even in existing circumstances in the better land, i.e. the isolated higher land but there is very little of it. That shows that there is nothing against its being grown. I do not think it is possible to drain the extreme south of the tract as it is only six feet above sea level and the sea is sixty miles away. There has never been much cultivation from the Fuleli escape. Six years ago, there were seventeen acres, I think, and now there are 200 acres so that there is practically no cultivation done from it now. The whole of the northern portion of the district is suitable for cotton as well as the eastern and north western. The gross area commanded would be about eight lakhs of acres of which I should think five and a half lakhs are culturable. At present *bajra*, *juar* and other *kharij* crops are being cultivated and, in the *rabi*, a certain amount of wheat and oil seeds. The land south of Badin at the southern end of the Fuleli is lower than that at the southern end of Jamrao. I should say it is about twenty feet lower. The time

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at which the cultivators can get flow water for sowing varies every year. This year, for instance, they did not get flow water till the end of June. In an average year they get it by the 10th of June. Then they begin to put their cotton in. The reason why cotton does not extend more is partly due to price and partly to the fact that, in the Fuleli district, cotton is one of the secondary crops. Every *zamindar* grows rice if he possibly can. He only grows other crops when he cannot grow rice. For instance, out of four lakhs of acres cultivated on the Fuleli, 2½ lakhs of acres are under rice. These are last year's figures. Rice has gone up in the last ten years from 1.62 to 2.71 lakhs, the other crops remaining practically stationary. In lower Sind the rice is a poor quality; it is chiefly the red rice. It is transplanted and also sown broadcast. In the southern portion of the district, in the *Lar*, (the local term for the southern part of the district), below Badin, more rice is sown broadcast than is transplanted. There is no hope of an extension of cotton on the Fuleli in the immediate future. So long as there is an ample supply of water, rice will be grown.

3750. I was on the Begari Canal which is one of the chief canals in Upper Sind for some time. The canals are opened in the first few days in June every year. They were cleared in the old weather after they stopped flowing. Occasionally the Begari Canal has to be closed. It is not the practice to let down water at the beginning of the inundation season to soften silt and then to excavate it. There is practically no cotton there. I think I once saw ten acres. I was there six years ago; at that time there was no question of the increase either of cotton or any other crop. I do not think they get their supply of water early enough to enable cotton to be grown there. The supplies at the beginning of June do not give flow water for some time except at the tails of the canals which are again rice land. The soil on the Begari is very good except that there is a lot of *kalar* in the lower parts and in the extreme north.

3751. (Mr. Roberts.) The main reasons against the extension of cotton are the difficulty of sowing early enough on the inundation canals and the disinclination of the *zamindar* to grow it. The *zamindar* prefers rice to anything. Rice can be safely sown much later and it can be transplanted much later. Although it is a much safer crop owing to the water supply being more suitable for it. The *zamindar* has a longer period for transplantation and if he anticipates a fall in the river, he can give his crop a very heavy watering and bring it to maturity. It is in every way a shorter crop than cotton. With an assured supply earlier in the season. I think the cultivation of cotton would extend. The ordinary *deshi* cotton is sown at the end of May. They would not begin sowing earlier, even if they had the water.

3752. My objection to increasing the intensity of the cropping on the Fuleli is that it would waterlog the country, as there would not be sufficient drainage. The watercourses in the field are the most important factor in adding to the water table. I am speaking of the Fuleli itself. There are so many watercourses and they are so much in excess of requirements that they waste water. Apart from the objection on the ground of water logging, I do not think that the labour for increased cropping could be obtained. The labour question is now very acute. *Zamindars* have not got *haris* enough to increase their present cultivation. Weeding is chiefly done by imported labour; and there is no assured supply of imported labour. The labourers come from the desert, and immediately there is any rain, they go back again. They do not come for cultivation, only for weeding. They are not recognised *haris*.

3753. (Mr. Hodgkinson.) I have not got the figures for cotton under the Fuleli for 1917-18 but I think the area this year will be about 20,000 acres. It would have been greater only the river rose so late and many lands intended for cotton were cultivated with *bajra*. There was no American. The Fuleli is a perennial canal. They are getting flow water now for wheat. Wheat has gone up very considerably since we started rotation on the Aliporo regulator. The cultivation of wheat has increased by 18,000 acres in the last two years. It went down to 9,000 acres in 1913-14 but it is now up to 28,000. Practically the whole of the increase is due to the system of rotations started on one regulator of the canal. The cultivators cannot get water for the early sowings in May. The Fuleli is seldom closed. It is now closed half way down for the construction of a bridge. Its last closure was in 1912 and that was due to the silting at the mouth. There is no difficulty about giving water for the American cotton along the main canal and on branches which may be flowing but the water has to be lifted. The Fuleli is more like a river than a canal. The trouble about the cultivation of cotton on the Fuleli is the competition of rice; that is the chief factor against an extension. You can not get the flow water for cotton in early April and you have not got an assured supply whereas there is direct flow for the cultivation of rice at the tail of the canal.

Mr. C. M. LANE, Executive Engineer on special duty, Karachi.

EXAMINED AT KARACHI, JANUARY 21ST, 1918.

Written statement.

I.—AGRICULTURAL EXPERIENCE.

"Deshi" short-staple cotton.

3754. (1) Experience.—I have held charge of the Jamrao Canal District for four years where I was in touch with the cultivators, both Sindhi and Punjabi.

3755. (2) Varieties.—I believe mostly common Sindhi short staple cotton is grown.

3756. (3) Size of holdings.—An average holding would probably be about 300 acres, but I have no exact figures. There are a large number of 2-block holdings (32 acres) on which Punjabi *abadgars* have been colonized. A Punjabi would probably put one-fifth to one-fourth of his holding annually under cotton and a Sindhi one-eighth to one-fifth.

3757. (4) Yields and profits.—I should put an average outturn at six to eight maunds of 80 lbs per acre. Assuming the value of seed cotton at Rs 8 per maund, the value at seven maunds per acre of crop would be Rs. 56. On "flow" land, the *zamindar's* share is one-half of the produce=Rs. 28. His assessment will be about Rs. 3-8-0 per acre and his expenditure on seed, watercourse clearance and extra labour for weeding and picking about Rs. 7-8-0 per acre, leaving a net profit of Rs. 17 per acre. I would estimate the average profit per acre from Sindhi cotton irrigated by "flow," under ordinarily favourable conditions, at from Rs. 15 to Rs. 20.

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3758. (5) Rotations and manures.—The Sindhi does not ordinarily rotate his crops. No *rabi* crop is usually grown on the land on which cotton has been the *kharij* crop. I have not known Sindhis to manure their cotton growing land. Punjabis, as a rule, sow a clover amongst the cotton plants on their last watering. This serves as a green manure and also provides fodder for cattle. They do not as a rule manure their cotton fields, but I have known them to do so with village sweepings of cattle dung.

3759. (7) Conditions affecting increase in area.—I do not think there is any appreciable fluctuation of the Sindhi cotton area. Any such fluctuation would probably be influenced by the sufficiency or otherwise of the canal supply in May and June. An extension of the area of Sindhi short staple is undoubtedly possible and would be effected by more economical methods of using the canal supply and a curtailment of the present wastage and overwatering.

3760. (8) Uses of seed and seed selection.—The *phutis* (unginned cotton) are sold to the cotton-buying firms through their agents or through the village *banias*.—The *zamindars* or cultivator does not retain the seed or, as a rule, have it returned to him though I believe that Messrs. Ralli Brothers do return seed to the sellers of cotton ginned at their factories at some reduction on the purchase price. This seed is presumably all machine ginned. Ordinarily the cultivator buys his seed each year and I do not know of any seed selection being practised.

3761. (9) General economic conditions.—The Sindhi is a notoriously wasteful and unenterprising cultivator. With more economical use of water, improvement in agricultural methods and implements, as a result of extended instruction and demonstration on the part of the Agricultural Department, I imagine that there is scope for a very large increase in the area under cotton on the left bank of the Indus in Central Sind and in those parts of Upper Sind where rice is not already firmly established as the staple *kharij* crop and also on new land to be brought under command of the contemplated perennial left bank canal. Probably the dearth of agricultural labour in Sind constitutes the most serious obstacle to an extensive increase in the cotton area, but with assured profits and accessible markets, it should be possible to persuade even the Sindhi that it will be to his advantage to adopt western methods and implements with a considerable saving of labour. This difficulty should not therefore be insurmountable and its solution rests with the activities of the Agricultural Department.

V.—GENERAL.

3762. (47) Effect of water rates.—In Sind the favourite crop is rice. To popularize cotton at the expense of rice would necessitate the increasing of the rice rate of assessment to a prohibitive figure and for some years at all events to assess cotton cultivation at a very moderate rate until (if this objective is ever attainable in Sind) the popularity of cotton cultivation has become established.

3763. (48) Desirability of alteration in water rates.—With the object of enforcing the economical use of water, I would very considerably increase the rice rate of assessment. When an assured perennial supply has become available, an all round raising of rates of assessment will undoubtedly be possible and necessary to render extensions and improvements of irrigational facilities financially practicable.

3764. (49) Effect of tenure of land.—The Sindhi custom of the cultivators sharing the produce with the *zamindars* results in the former having considerable authority in the matter of crops to be grown and the areas to be brought under cultivation. The Sindhi *zamindar* is, in consequence, frequently not his own master in these matters.

VI.—IRRIGATION.

3765. (65) Experience.—My experience in Sind covers four years only in charge of the Jamrao Canal and ten years on inundation canals in Upper and Lower Sind, where no cotton is grown. I have had no experience of assessment work which is the province of the Revenue Department in Sind.

3766. (66) Watering of cotton.—Cotton is watered from May to October. The average of a number of crop-watering experiments conducted by the Public Works Department in Sind gives the requirements for cotton as seven waterings of five inches depth and a duty of 65 acres per cusec of water supply on the field.

3767. (67) Cotton versus wheat.—The cotton and wheat crops are not simultaneous. The Sindhi has, however, no great partiality for *rabi* cultivation and does not grow a large area of wheat.

3768. (68) Fluctuations in river supplies and their effects.—The rise of the Indus in April-May is normally gradual, the highest level is usually attained at the end of August or early September and a fair irrigating level is available till the middle or end of September, the fall normally being gradual.

(2) The cultivator's crop programme must have been decided on before he could be influenced in this connection by the regime of the river. He would ordinarily be ready to take advantage of an early rise to sow as extensive an area of cotton as possible. A late rise would probably result in a large proportion of the area intended for cotton being sown with *bajra* or *juar*.—I am not, however, in a position to be able to supply either a diagram or statistics in this connection.

3769. (69) Wells and tube wells.—In Upper Sind there is some area of wheat (*rabi*) cultivated on wells, but I have no knowledge of its extent. I do not consider any large extension of well irrigation to be practicable as being most expensive and requiring heavy initial outlay of capital.

(2) I have no experience of tube wells.

3770. (70) Suitability of existing water rates.—I consider that an increase of rates of assessment on cotton is generally possible and necessary in Sind, vide my answers to questions 47 and 48. (paragraphs 3762 and 3763)

3771. (71) Cropping and causes affecting it.—The cropping of a Punjabi cultivator, holding 100 acres would be roughly as follows:—

Cotton, 25 acres.

Wheat, 32 acres.

Sugarcane, maize tobacco, garden crops, etc., 8 acres.

Fallow 35 acres.

That of a Sindhi cultivator, holding 100 acres would be—

Cotton, 20 acres.

Wheat, 12 acres.

Garden crops, etc., 6 acres.

Fallow, 62 acres.

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The area under cotton is chiefly influenced by the available early supply and that under wheat by the available surplus supply at the time of the last cotton watering in October. The above proportion represents the distribution of crops in a year of good average conditions and I doubt whether it would be at present possible materially to improve it except as contemplated in my answer to question 9 *ante*. (paragraph 3761)

3772. (72) Adequacy of supplies to increase in area under cotton.—I do not consider that sufficient water is at present available in Sind canals to allow of any large extension of the area under cotton, excepting such as would become possible with more economical use of present available supply.

3773. (73) *Deshi versus American cotton*.—I understand that cultivators in Sind are not partial to growing American cotton. They are extremely conservative and in addition are, I believe, under the impression that more trouble is involved in tending and weeding the plants and that these are more susceptible to boll-worm than the indigenous variety.

3774. (74) Effect of canal regulations.—I do not know of any canal regulations which create difficulties in regard to the irrigation of American cotton.

Mr. C. M. LANE called and examined.

3775. (Mr. Ashton.) The usual time for sowing Sindhi cotton on the Jamrao canal is about the 10th May. The assured supply of water during March and April is sometimes not as much as is wanted, owing to silting trouble. Normally there should be an assured supply. Owing to the silt clearance lately, I think that there should be plenty of *rabi* water and sufficient supply in March, April and May. Silt clearance is not done frequently. It was done for the first time last year. I am not sure for how long the canal was closed but think it was about six weeks. Normally, there is sufficient supply of water in the Nara supply channel except in a very low year. During the five years I was on the Jamrao there was only one occasion on which the supply was short. If silt comes into the canal again, measures will have to be taken; if silt can be kept out the canal, there would be no necessity for any other measure.

3776. The inundation canals in Upper Sind are usually opened between the middle of May and the 1st of June. Under present conditions, nothing could be done to get an assured supply of water earlier for staple cotton. I mean that the canals are opened as soon as they can flow. It is not a question of the canal being ready in time. They are kept closed until the river is high enough to allow them to be opened. It is the level of the river which settles the question of opening. The only solution is the Rohri Hyderabad Canal. Personally I think from what I have read in the reports that the Sukkur Barrage is absolutely necessary.

3777. There is not much cotton grown in Upper Sind on the right bank. The Upper Sind districts of which I have had experience, the Ghar and Shikarpur Canals, had practically no cotton in them. There the chief crop is rice. The barrage would give those canals an early water supply, and would certainly benefit them. There would be a chance of extending the cultivation of cotton when they get that supply if the cultivation of rice could be made unprofitable. At present the rice grown under the Ghar and Shikarpur canals is the best rice in Sind and therefore a very profitable crop and it would be very difficult to eradicate it.

3778. A supply of water could not be given by pumping from the canals except in the case of one or two of the larger canals. The Karachi canals district has got three large canals, the Baghar, Pinyari and Kalvi canals. They carry an early supply and water could be lifted from them by pumping. The Baghar and Pinyari canals are never closed at all. They usually flow from somewhere about the middle of April but not at flow irrigating level. The *zamindars* there do a good deal of lift irrigation at present. Along the banks of these canals it is usually sugarcane that is grown on lift. The other lift irrigation is for *bagra* and *juar* in the *kharij*. There is no cotton in the Karachi district at all. The cost of pump irrigation as compared with canal irrigation has not been worked out.

3779. The Sukkur Barrage would undoubtedly have some effect in improving the supply on the Jamrao and the Eastern Nara. It is necessary to have the barrage from their point of view.

3780. (Mr. Henderson.) I have seen a little of the American cotton growing on the Jamrao. From what I have heard about it, it seems that the Sindhi is rather nervous about it. He thinks that it entails more labour and wants more trouble taken over it and that it is more susceptible to attacks of boll worm. Whether it is so or not, I do not know. This opinion may be due to the fact that the *haris* are not particularly keen on it. The *hari* is the man who farms opinion in Sind. On the whole, there is a shortage of *haris*. Much difficulty is caused by one *zamindar* taking away another's *haris*. In the Karachi district, it is a frequent occurrence. The man whose land is not favourably situated does not get a good crop because he is never able to keep his *haris*. There are some remedies under the law if the *haris* go away. I do not know exactly what they are but the *zamindars* can take the case to the Civil Courts. There is no summary law.

3781. As regards the yield of American cotton, I tried to get some figures from the southern districts of the Jamrao. They say that the yields are four to five half maunds per acre but I fancy that that is an underestimate. I have not heard anything about the premium obtained for the cotton. If there were a big premium for American cotton over *deshi*, I do not know of any agricultural reason why American cotton should not extend, provided, of course, that water were available in April and May. Not very much *deshi* cotton is sown on the Jamrao in April. I fancy that the Punjabi would always sow it in April if he had the opportunity. The Sindhi might or might not as he is not used to it. The reason given for sowing early is that the yield is better. The Punjabi thinks that cotton sown in April will not want water so late and that he will have his late water for wheat. I have seen watering given up to the end of December, but not as late as February. It is quite likely that some cultivators put on water not for the sake of the cotton but for the sake of getting leaves for fodder for the cattle. As to the best yield of cotton, I think I have heard of ten or eleven maunds in the case of *deshi*. That is the best that I have heard of. In my time, wheat cultivation was going up. But that was five years ago. When the Nara supply channel was closed for clearance, it went very low but it was gradually recovering. If the cultivators got a really good price for American cotton, I think they would extend its cultivation on the Jamrao. I see no reason why its cultivation should not extend.

3782. I do not think that on any inundation canal you can guarantee early water. If American cotton can be sown as late as May, then it can be grown on several of the inundation canals. The Fuldi used to be a perennial canal but it is not so now, except for a perennial trickle in its bed, I believe. It carries a certain amount of water which can be lifted in the cold weather but as far as an irrigating level is concerned, it is not perennial.

Sind.]

Mr. C. M. LANE.

[Continued.]

3783. In a normal year, I should say that American cotton could be sown on the Nasrat, Fuleli and Mithrao. In the Larkhana district, I noticed cotton being sown in places where it was not grown before. I have had no connection with Upper Sind for eight years.

3784. Much of the Karachi District is said to be waterlogged. There are large areas in the Sujawal Taluk on the left bank of the river which are absolutely waterlogged. The height above the sea level is about 21 ft. The distance is about forty miles from the sea. The cultivators say that cotton can not be grown at all in the Karachi District and neither can wheat. I do not know why. I do not know whether this is merely a prejudice. I should think that there is scope for trial and for demonstration work, and that the Agricultural Department could be considerably extended in Sind. In the Karachi District, the Agricultural Department is practically not known to exist. There is merely an annual cattle show which has nothing agricultural about it. There is great scope for the expansion of the Agricultural Department in Sind generally. I should say there is room for several more demonstration stations and for several more trained men to tour about the country and give advice generally.

3785. The great advantage with rice in Larkhana is that it is quite a different rice from that grown in other parts of Sind. The Larkhana rice is certainly the best rice in Sind. It is very well cultivated and gets a much bigger price. The other rice—the red rice—is on a different level altogether. It is very inferior. The *kambar* rice pays much better than red rice. As to whether there should be distinct rates for the different varieties of rice, I should say that that is a question for the Revenue Department. I think that well cultivated rice ought to be differentiated from broad-cast rice which is wasteful of water. I am against broadcast rice, except where nothing else can be grown, i.e., on *kalar* land. Presumably it would have to be allowed there. It might be feasible to grow rice in rotation. In Upper Sind, the Sindhi grows gram and matar after rice.

3786. The intensity of cropping on the Jamrao is one-fifth in *kharij* and one-eighth in *rabi*. If the water were available in time, we would get a higher intensity. The Punjabi would certainly exceed that intensity and even does so on the Jamrao. The canals when designed were presumably based on the intensity of cultivation in Central Sind. The intensity is much higher in Upper Sind. I could not say whether we should be well advised to allow a higher intensity. We have been discussing that question. I do not think that the Jamrao as designed can be a great success because its intensity was fixed so low. It would have been a greater success if a higher intensity had been allowed for it. The Punjabi on the Jamrao works to a considerably higher intensity than one-fifth or one-eighth and the Sindhi just about reaches it. I have no information whether the yield on the Jamrao is going down or not. It is rather a difficult question to decide what intensity should be allowed. It is essential to have proper rotations but to give proper rotations the Jamrao would have to be designed differently. In Sind as a whole I do not think it is ever likely that the *rabi* cultivation will exceed the *kharij*, though it may possibly equal it. Under those conditions you would always have to design for the *kharij* supply. One can always enlarge a canal but one has to pay for it. It would be feasible to enlarge the Jamrao but whether it would be a paying proposition is another question. I do not think that there is much spare water now with the demands of the Mithrao as well. It is difficult to say why there was silting at the head. It was possibly due to the regulation not being properly attended to. There is no absolute reason why it should occur. It is certainly preventable. The effect of shutting down for a considerable periods is to destroy the confidence of the *zamindars*.

3787. I do not think there is much good land left on the Jamrao to be given out but they are still giving some to military pensioners. The Punjabi cultivator is better than the Sindhi. The *abadgarh* is certainly the man who does the best cultivation both for cotton and wheat. He looks after his land better throughout the year and make his water go further. He does not allow his land to lie fallow. In some cases I have seen Sindhis benefiting by the example of the Punjabi when a Sindhi village is next to a Punjabi village. The Sindhi does improve somewhat. But there are some pretty bad Punjabi *zamindars* on the Jamrao. Many people say that the Punjabi is falling to the level of the Sindhi instead of the Sindhi improving to the standard of the Punjabi.

3788. *Kalar* in Sind is a very serious problem. The Sindhi usually says that land which shows traces of *kalar* is fit for nothing but rice but I think he is wrong and that if these lands were properly ploughed and tilled, they would be fit for wheat and cotton. I could not say whether *kalar* affects the texture of the land. A trace of *kalar* is not detrimental to cultivation. There are excellent crops on land that shows traces of *kalar* on the Upper and Lower Jhelum. The land requires only careful treatment and may possibly at first want more water.

3789. The "duty" in Sind is bound to be lower than it is in the Punjab. The *kharij* duties are not unfavourable compared with those in the Punjab. There is no proper *rabi* duty as the supply available is not fully used owing to the smallness of the *rabi* area.

3790. (Mr. Roberts.) The cotton cultivation in the Punjab is very much better than that in Sind. I think the land is generally very much better prepared than I have seen it anywhere on the Jamrao. There is a great deal less weed and grass in the fields. The question of the intensity is what determines the size of your channels; if you are going to allow a high intensity and the relation between the *kharij* and the *rabi* area to be almost the same as at present then the canals would have to be designed to carry a bigger *kharij* supply. That would be very difficult to work in *rabi*. The question of intensity of cultivation depends on the period at which the different crops want the water. I do not think it would be hazardous to work on the basis of 100 per cent as the minimum intensity—say two-thirds *rabi* and one-third *kharij*. It would be easier to work your canal; but if the proportions were the other way round, it would be practically impossible to work it. There would not be any irrigational difficulty in increasing the intensity to 200 per cent provided the supply were available in the river.

3791. In Sind, for an extension of the cultivation of American cotton, it is essential that there should be a sufficient early supply available. The cultivator would prefer to sow cotton if he could get water as early as March and April. I have seen cotton much affected by cold owing to late sowing.

3792. (President.) The laziness of the Sindhi cultivator is his inherent feature and it is probably partly climatic. If there was a perennial water supply as there would be if the barrage were constructed, there is a possibility that that would stimulate the Sindhi cultivator to go in for more cultivation. The degree of laziness of the Sindhi increases from Upper Sind down to the delta. The worst Sindhi cultivators are to be found down in the delta. The cultivator in Upper Sind is not lazy but works hard.

Sind.]

Mr. A. B. TIMMS.

Mr. A. B. TIMMS, Executive Engineer, Jamrao Canals, Northern District, Sind.

EXAMINED AT KARACHI, JANUARY 21ST, 1910.

Written statement.

VI.—IRRIGATION.

3793. (65) Experience.—I have served in the following districts, and my whole experience in the Public Works Department during my eight years' service has been gained in Sind :—

Ghar Canals District.
Indus River Commission.
Eastern Nara District.
Begari Canals District.
Hyderabad Canals District.
Jamrao Canal District.

In the last mentioned district, I have been nearly three years, so that I proposed to confine my remarks mainly to this period. I have no experience of canal assessment work.

3794. (66) Watering of cotton.—The season for sowing cotton starts from the beginning of April in this district, when *zamindars* plant *arhari* (spring) cotton, also American cotton. But as the water supply is not sufficient at that time, the sowings of Sindhi cotton generally start from the middle of May and continue till the middle of June or even later.

(2) For cotton, a preliminary watering of about 14,500 cubic feet=4 inches, is given to the land. The first watering is given from thirty to forty days after sowing, and this is about 11,000 to 12,000 cubic feet (3 inches to 4 inches). The subsequent waterings are given at about ten to fourteen days' intervals, varying from 8,000 to 10,000 cubic feet (2 inches to 3 inches). The volume of water used and the intervals allowed to elapse between successive waterings of course depend on various causes, such as the nature and retentivity of soil, temperature of the air, condition of ground (whether level or uneven) etc. The crop is said to require water as soon as the plant begins to look withered or "thirsty" and the soil near the roots becomes dry. In all, about eight to ten waterings are given on well-managed land and ten to twelve waterings where less care is taken, but this also depends on the soil and rainfalls.

(3) On the whole, Sindhi cultivators are inclined to overwater their cotton crops. The Punjabi is more careful and economical. He also levels and prepares his land better than the Sindhi.

3795. (67) Cotton *versus* wheat.—On the Jamrao Canal, cultivators prefer cotton to wheat. The reason for this is that cotton fetches a higher price and is a more paying crop. It requires more care and trouble and the expenses for weeding are also much heavier, about Rs. 15 of more per acre, depending on the labour available. It is not very suitable for *kalar* land, for which wheat is better adapted. But it is a *kharij* crop and the Sindhi cultivator must have a *kharij* crop to keep him employed. Being used to inundation canals, he is not accustomed to extensive *rabi* cultivation like his Punjabi fellow-cultivator. The other *kharij* crops which he might sow are *juar* and *bajra*, but these are not so paying as cotton, particularly just now when the rate of the latter is so high. The result is that the Sindhi cultivator goes in for cotton cultivation. The Punjabi likes wheat, as it forms his staple food, and he brings his ideas from the Punjab where it is extensively cultivated. On the other hand, the *rabi* supply on the Jamrao, due to the vagaries of the Indus, is subject to fluctuation, so that there is always the risk of a deficient water-supply, which also prevents *zamindars* from sowing wheat on a larger scale.

3796. (68) Fluctuations in river supplies and their effects.—The river is at its lowest during December, January, and February and the beginning of March. By the middle of March it begins to rise slowly, and by the end of March or beginning of April it steadily increases till the middle of August, when its maximum is reached. It then commences to fall rapidly till the middle or end of October, after which the fall is more gradual till the end of December, when it reaches its minimum.

(2) The diagram attached (Annexure I,* shows Hydrographs of the River Indus for Bukkur and Kotri for varying periods extending over the last seventy years, and these clearly show the behaviour of the river. Generally speaking it may be taken that the rise is gradual and the fall sudden.

(3) The effect of this is that cultivators on inundation canals prefer to do rice, *juar* and *bajra* instead of cotton, the reason being that they cannot rely on a full supply of water for the period necessary for the requirements of the cotton plant, extending over eight months, about.

(4) On the Jamrao Canal, an early rise in the river affects the cotton area and increases it. Also, an early and sudden fall affects the wheat area and decreases it. Being a perennial canal, it is not so dependent on the fluctuations of the river as inundation canals.

3797. (69) Wells and tube-wells.—There are practically no wells used for irrigation of crops in the Jamrao Canal District. They are only used for drinking purposes and for gardens, and are insignificant in number. It would not be worth while taking steps to extend irrigation on wells in this tract, as it has a perennial supply from the Jamrao Canal.

(2) I have no experience of tube-wells. There is no scope for them in this district.

3798. (70) Suitability of existing water rates.—Speaking for the Jamrao Canals District, I am of opinion that the existing assessment, which includes water-rates charged for cotton, is low. Cotton requires much more water than *bajra*, and it is a more paying crop. In my opinion, the rate should be increased. If, however, Government decide to extend the cultivation of long-staple cotton, it would not perhaps be advisable to increase the rate till the long-stapled variety has established its popularity and *zamindars* have begun to take to it readily. The rate may be raised three or four years after a proper start has been made with this cotton and cultivators have found out from experience that it is a profitable crop.

* Published in separate volume of maps and plans.

Sind.]

Mr. A. B. THOMS.

[Continued]

3799. (71) Cropping and causes affecting it.—The average annual distribution of cultivation on the Jamrao Canal for the last three years is approximately as follows:—

	Acres.
Culturable area	776,000
Cotton area	105,000
Rabi	100,000
Other <i>kharif</i>	65,000
	270,000

The average area annually cultivated per 100 acres holding is roughly as follows:—

	Acres
Cotton	15
Rabi	12
Other <i>kharif</i>	8
	35

(2) These areas are affected by the water-supply to the extent that a good supply would increase the area under cotton and wheat and also fodder crops (*vide* the concluding paragraph of my reply to question No. 53). The increased intensity of cultivation would have to be provided for by setting aside a sufficient area for restorative crops, such as *berseem*, and a more widespread adoption of scientific methods of crop rotation and manuring.

(3) I have not put forward any proposals hitherto, but I would here state that the troubles arising from a precarious water-supply in Sind would be mitigated to a great extent, if not entirely overcome, by the construction of a barrage across the Indus at Sukkur. The fluctuations of the river and the disadvantages due to late rises and early falls, so prejudicial to any extension of the area under cotton in Sind, would then be obviated to a great extent by the advantages of being able to pond up water. The resulting assured supply would give an increased area even with the present intensity of population which should also increase with the construction of new canals, and the advent of colonists. My remarks apply to canals in Sind generally.

3800. (72) Adequacy of supplies to increase in area under cotton.—The supply in the Indus is at present uncertain as stated above, and until cultivators can be guaranteed an assured supply, no increase in the area under cotton can be expected. The high price ruling at present might tempt them to sow more cotton than they would otherwise do under normal conditions, but in such cases they know they are taking a risk.

3801. (73) *Deshi versus American cotton*.—Cultivators prefer *deshi* to American cotton for the following reasons:—

- (1) American cotton requires to be planted early in the season in April or May when water is not obtainable in inundation canals. Even on the Jamrao canal, which is perennial, the water-supply at the time is low and rotations have to be enforced.
- (2) American cotton is more susceptible to the ravages of boll-worm, frost and disease than the indigenous variety, as it is more delicate.
- (3) It requires more labour and trouble to cultivate American cotton. This is a very important factor with the lazy Sindhi *zamindars*.

Mr. A. B. THOMS called and examined.

3802. (Mr. Ashton.) The Sukkur Barrage would improve the water-supply in the Jamrao: It would give early water and a more assured supply. The widening of the Nara as well as deepening it might have the same effect. I do not think that it would be wise to depend only on the Rohri Hyderabad Canal without the barrage. To get a really satisfactory and assured supply at all seasons for the Jamrao Canal, we must have the barrage. The barrage would of course affect all the canals which are at present designed to come under the Rohri Hyderabad scheme in the same way. There is some lift land on the Jamrao which is being gradually converted into flow land. There is no well irrigation there except for gardens. Just round about Mirpurkhas there are a few petty *zamindars* who cultivate a few acres of *bajra* by means of well irrigation but that is quite exceptional and it is chiefly for garden purposes that well water is used. Cotton is grown in the Eastern Nara district, where the conditions are the same as on the Jamrao. The water in the Nara is divided between the Jamrao and the Mithrao. When the supply is low, the Jamrao gets two-thirds and the Eastern Nara system one-third of the water. All that part would be greatly improved by the barrage. The Hyderabad Canals district is a very old district. I do not think there would be much increase of irrigation there from the old canals but if some of the land were put under the Rohri Hyderabad Canal it would be affected.

3803. There is danger of waterlogging on the Jamrao. They say that the tract has become much more malarious since the introduction of the perennial system owing to waterlogging. The well measurements show that the subsoil water level has risen. In December 1916, the water had risen in seventeen wells and fallen in eight since May, 1916. In May 1917, the water had risen in six wells and fallen in 23 since December, 1916, but that was due to the fact the Jamrao was closed for 2½ months. The sub-soil water has risen appreciably since the construction of the canal. Mirpurkhas is 45 miles from Hyderabad and about 150 miles from Karachi. It is about fifty feet above sea level. The depth of the sub-soil water is about twelve to fifteen feet. There are no tracts on the canal which are absolutely waterlogged, *i.e.*, in which water is only four to five feet below the level of the surface.

3804. I consider that an assured supply would mean an increase in the area under cotton and wheat and also fodder crops. With the present discharge in the canal and an early supply in April, or May, the cotton area would go up and then when the river drops suddenly in September and October, if you could maintain a good supply in the canal, the *rabi* area would go up.

3805. I think the rates could be raised now except for the unsettled state of the country. I think that the rate for cotton is too low and that with an assured water-supply it could be raised. The assessment for cotton is Rs. 4, Rs. 3-12 and Rs. 3-6 per acre for first, second and third groups. That is the rate for flow irrigation: for lift it is ten annas less. It is a consolidated rate and there is no separate water-rate. I put

Sind.]

Mr. A. B. TAMIS.

[Continued.]

in a statement (Annexure I) showing the rates of assessment in the Jamrao tract. The Punjab rate of assessment, i.e., land revenue and water-rate consolidated is about Rs. 8 on an average. I do not think that the Sindhi could pay as high as the Punjabi, at any rate not at once. Given the same conditions of water-supply, the rate in Sind might be worked up to much more than it is at present but I think that Rs. 8 would be too high to expect. We have got better land here than in the Punjab, but labour is very much more difficult to secure and we have not got the rainfall they have in the Punjab. The question of pressure on the soil also comes in. The smaller the holding, the more a man has to work.

3806. (Mr. Henderson.) I have seen American cotton growing on the Daulatpur Minor. The land was given out on the special conditions that the *zamindars* should grow American cotton. When I came to the Jamrao in 1915, it was growing there but it did not do very well that year because the Minor had to be cleared of silt and they got water late. I think American cotton should do very well in Sind. I have seen some growing on the seed farm. What I saw was quite vigorous and healthy. On the Daulatpur Minor, it was sown earlier than *deshi*. There is nothing against its spreading very largely, if it gets a good price and a good market. A good price is the main thing and that it has not had in the past. As an agricultural proposition, it is quite safe. I have not seen any American cotton on other inundation canals.

3807. The Jamrao was closed in 1911 during March and April in connexion with the remodelling scheme; it was also closed last year for 2½ months from 15th March to 25th May for the removal of silt deposit in the first twelve miles. That leads to lack of confidence on the part of the *zamindars*. The *zamindars* are used to clearances. They have experience of them on inundation canals but they are used to cold weather clearances. Minors can be cleared without much inconvenience. The clearance is usually done in the *adawa* (spring) season between *rabi* and *khari* when there is very little cultivation. It might have the effect of preventing cold weather fodder crops being grown but I do not think that a very serious matter. The main reason for insecurity is the precarious supply in the Nara. There is a feeling among the Jamrao *zamindars* that the supply in the Nara is not to be relied upon. There is considerable difficulty in some years with labour; that is one of the chief problems. First of all, there is the difficulty with the *haris*. In a year of heavy rainfall like 1917, the labourers that come from the desert—the *Tharis*—immediately return to the desert to do cultivation there after the rainfall and there is very little outside labourer left here to carry out the weeding operations. Malaria is also very prevalent after heavy rains and this incapacitates the labourers. It is not very common for the *zamindar* to take away the *haris* of another *zamindar*. The *zamindar* think that the giving of advances to their *haris* is a very bad system because the *haris* go off with the advances and they cannot get them back without going to court and that is very troublesome. If the *hari* goes off to a Native State such as Marwar then nothing can be done. This year was a very exceptional year. The price of labour for picking and for hoeing went up; in some cases the *zamindars* paid Rs. 15 per acre for hoeing. That was for two operations. That is abnormally high as ordinarily the charge is about Rs. 6 to Rs. 8 for two hoeings. This year has been a very bad year for cotton owing to the damage to the crops by heavy rain: there was also frost at the end of December which did a lot of damage. So the average outturn this year is very bad, and is only about two maunds an acre. Some of the *zamindars* sold their cotton early at about Rs. 12 a maund; those persons who relied upon a certain outturn and sold their crop in advance lost very heavily, as they had to make up the difference at the rate of Rs. 19 i.e., they had to pay the difference of Rs. 7 out of their own pocket. That ruined several *zamindars*. There are some *zamindars* on the Jamrao who are not very well off whilst there are others who are doing quite well.

3808. I do not think that the yields on the Jamrao are going down: they are about stationary. Under the present system of cultivation without proper rotation of crops or systematic farming and also with an uncertain supply, one-fifth in *khari* and one-eighth in *rabi* are quite good figures for intensity. In some cases, where you find small Punjabi *abadgars* owning 32 acres of land and two bullocks, although they only get water for one-fifth and one-eighth, they do more than that in practice. It may be possible that they sometimes do get more water. It is impossible to give more water than the allowance of one-fifth for *khari* and one-eighth for *rabi*. On the proposed Rohri Hyderabad Canal, I should give one-third in *khari* and one-fourth in *rabi*.

3809. I know the general character of the land in Upper Sind and think the soil is better than that on the Jamrao. I have seen *bosi* wheat in Upper Sind, i.e., wheat grown on inundation canals by giving the land one watering at the end of the inundation after which it is ploughed and drilled. *Sailabi* wheat does very well. You could not grow *bosi* wheat on the Jamrao as the land is of a different texture. That is of course a very important factor as regards the new canal. I think that there should be a thorough soil survey by a botanist or agricultural chemist.

3810. The Nara supply used to be silted by the floods from Ghotki; now a flood diversion *bund* has been built near Rohri and these floods are diverted. The Nara supply channel was silted up one year (1909) and that gave trouble and the Jamrao could not get any *rabi* water then. There were floods in 1907, 1908 and 1909. The Jamrao gets water direct from the Nara. When the river drops in September and October, the discharge coming in at the Nara head is sometimes less than the discharge at Jamrao head, 100 miles lower. This is due to the fact that numerous *sangs* or *jhils* take off from the Nara. These get filled up at the time of the inundation and in the cold weather the water flows back into the Nara. This gives assistance in the *rabi* season. They are not to be relied on.

3811. Lift land is gradually being turned into flow land on the Jamrao. There are some lands which are called flow lands but which are aided by lift. There is a special rate of assessment for them. Even in some of the Sindhi villages which are commanded by flow, the people regularly lift water. They have to get permission to erect Persian wheels but if the land can get flow water it is refused. Many *zamindars* make their water courses very deep when they clear them and gradually convert flow into lift. They know that by digging deep they can get more water into their channels. The Sindhi *hari* has no objection to lifting water because he gets two-thirds share of the crop instead of a half. Another reason why lift is preferred to flow is that if a man has a very small area, his turn in the rotation might be for two or three hours only and might come at an inconvenient time, for him. He thinks two or three hours flow does not give him sufficient water for his requirements and so he prefers to irrigate his field by a Persian wheel and to work it for the whole week.

3812. The soil round about the south of the Jamrao and the Eastern Nara is good. I have never considered the possibility of cotton growing there. There are huge areas of desert land. There is some cultivation. A certain amount of *barani* land is cultivated if there is any rain. The possibilities of irrigating the desert country were once considered, I believe, but the scheme was abandoned as impracticable.

